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ABSTRACT

The document was prepared to serve as a guide to adult educators and others interested in specific information relating to the National Aeronautics and Space Administration (NASA), and to provide a source of information of the breadth and scope of space explorations including space benefits to mankind. The course is organized into eight units of study: (1) the beginning of space exploration, (2) rocketry and propulsion systems, (3) unmanned and manned space flight, (4) to the moon and back, (5) Apollo mission results and practical returns from space investment, (6) the space program today--information and available resources, (7) basic scientific concepts relating to the space program, and (8) space programs. The format of each unit is the same: an introduction and rationale, a pre-assessment, and the unit objectives, followed by the unit's content in the form of an outline several pages in length; vocabulary, suggestions for the teacher, a listing of illustrative resources, and a post-assessment conclude each unit. Appended are a glossary, suggested learning activities, and a comprehensive examination. (Author/AJ)

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space awareness

an adult education curriculum resource guide

This public document was promulgated at an annual cost of $3,876.01 or $3.87 per copy to serve as an instructional guide for adult educators and others interested in specific information relating to the National Aeronautics and Space Administration and to provide a source of information of the breadth and scope of space explorations including space benefits to mankind.

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OVERALL SUGGESTIONS TO THE TEACHER

Nothing in the process of educating adults puts the student more at ease than to give him a test and tell him to answer the questions if he knows the answers, that it is an educational activity rather than a testing activity, that it does not have to be returned to the teacher, that in the course of the unit under study he will receive answers to the questions, that if at any time he has questions concerning the test he is free to consult the teacher, and finally, that at a given time he will be given answers to the test questions for self-evaluation. This we suggest for the pre-assessment activity. It is further suggested that the pre-assessment be given at the beginning of the unit, followed by the introduction of the unit. Along with the introduction of the unit, the words from the Space Awareness vocabulary should be given to the students. You should decide the most effective way to present the words after observing the class. Writing the words on a chalk board, duplicating word lists for handouts, or even pronouncing and spelling aloud for the students to write are some methods for consideration. An advantage in the use of the vocabulary is the use of the activity to promote study at home. Use this as a homework assignment without the pressure of the conventional work to be returned to the teacher. Use the word lists primarily to help the adult build a working Space Awareness vocabulary. Have the student define the words and add them to a notebook which he keeps for himself. Decide whether or not you want to conduct an activity of using the words in sentences after you observe the type of group you are working with. Many of the words can only be found in NASA publications which you will be able to acquire in quantity for use as handouts for your classes. When the student has a publication and the word list in his possession, his search for the words will certainly stimulate out-of-class reading. You have your complete glossary to refer to for really difficult and hard to find definitions to aid the student.

For lecture periods you should draw from your own experiences, from the outline as presented in this guide, or from NASA publications. Again the make-up of your class or group will dictate lecture material, how often lectures should be given, length of lectures, etc.

During the course of the unit, you should note the progress of your class as a whole. How well did they do on the pre-assessment? Are they continuing to seek answers to the questions? How are they progressing on the word list? Are they asking questions freely? Which activity stimulates the most interest (laboratory type activities, lectures, films,

field trips)? Answers to these questions will suggest courses of future action on your part.

It is suggested that periods of planning be spent by you and your students, as to how best to achieve the purposes of the unit. You must remain in control of the situation and guide the thinking of the group in the planning. It is well, however, for the adults to feel that they have a share in the procedure.

It has been suggested previously that the type, the make-up, or even the level of academic achievement of the adults you are working with, should dictate content, methods, techniques, etc. There is no area in which this procedure should be adhered to more than in determining the evaluation. To evaluate or not to evaluate? In some situations, you must of necessity evaluate (high school credit or completion). There will be other situations in which a formal evaluation will be questionable (general interest groups or Adult Basic Education classes). You should consider the post-assessment as a means of informal evaluation without the emphasis on pass or fail for some groups. The post-assessment could very well be used as a formal evaluation if circumstances warrant this. Another suggestion is that the comprehensive examination in the appendix be utilized all or in part, as the need arises, if this procedure produces desired results.

In addition to these overall suggestions, specific suggestions will be made for each unit.

UNIT I - THE BEGINNING OF SPACE EXPLORATION

INTRODUCTION

This unit presents some of the early theories and accomplishments in man's attempt to conquer space and shows that present-day successes were based on some of this early scientific work.

The beginning of space exploration must begin with the myths and legends of our earliest civilizations. Mankind's unquenchable desire to extend his horizons has its roots almost back to the beginning of time. This unit stresses the continuity of ideas and the progress as new theories were developed, tested, rejected or adapted and accepted. Our sophisticated rocketry of today has its roots in the past.

History tells us that flight has always challenged man's imagination. Most of man's early attempts with flying devices ended in failure. Some men were finally successful in flying their machines, but only after they began to understand and apply basic aerodynamic principles.

The technology of space exploration is a rapidly growing one. This unit also stresses the point that as modern as space flight may seem, most of the basic knowledge necessary for putting satellites into orbit or for launching an interplanetary space vehicle was given to us by Johannes Kepler and by Sir Isaac Newton (1642-1727) hundreds of years ago.

Even though rockets were born hundreds of years ago, only during the past decade were they actually used to lift

man into space after science developed better propulsion and guidance systems.

This unit will familiarize adult students with the contributions of Copernicus, Kepler and Newton. The students will also learn about the work of Leonardo da Vinci, the Montgolfier brothers, Henry Giffard, the Wright brothers, Galileo, and Dr. Robert Goddard during the course of the unit.

RATIONALE

The appreciation of the historical aspects incorporated within the study of space awareness allows the learner the opportunity to perceive the linear development of space travel. The realization that an extreme number of variables has affected the "space thinkers" of the past and the present certainly reveals the creative endurance necessary in the study of space exploration. Awareness of the struggle and the accompanying creations enhances the positive reinforcement involved in learning about space. The general public will be in a better position to understand and appreciate man's efforts to explore space if there is information available through this unit of early attempts to fly and explore the heavens.

PRE-ASSESSMENT

1. Match the following individuals and their contributions to space exploration. In the space before each statement in Column A, print the one letter from Column B which correctly identifies the person or persons responsible for the contribution.

COLUMN A	COLUMN B
_____ 1. Made the first practical use of the telescope to discover many new facts about astronomy.	A. Charles A. Lindbergh B. Leonardo Da Vinci C. The Montgolfier Brothers D. Henry Giffard E. Orville and Wilbur Wright F. Nicolaus Copernicus G. Galileo H. Johannes Kepler I. Sir Isaac Newton J. Sir William Congreve K. Dr. Robert H. Goddard L. Amelia Earhart
_____ 2. Studied bird flight and drew pictures of wings which he thought could be attached to the arms and legs of a man to enable him to fly.	
_____ 3. Founded present-day astronomy with his theory that the earth is a moving planet.	
_____ 4. Built and flew the first successful engine-powered airship.	
_____ 5. Called the "father" of modern rocketry.	
_____ 6. The first to build a successful balloon.	
_____ 7. Developed long-range military rockets that carried explosives during the early 1800's.	
_____ 8. Built a gasoline-powered airplane and flew it successfully in 1903.	
_____ 9. Discovered how the universe is held together through his theory of gravity.	
_____10. Discovered three laws of planetary motion.	

GENERAL OBJECTIVES

1. To acquaint the student with the origin of space exploration.
2. To bring about an awareness that the advances in space

exploration are the result of developments hundreds of years ago.

3. To promote interest in the further study of space exploration and its results.

SPECIFIC OBJECTIVES

1. Given the names of outstanding contributors to space exploration, the student will select the main contribution of each from a list.
2. From a list of vehicles driven by rocket power, the student will select the one which is acknowledged to be the first practical vehicle developed.
3. Given a list of events in the exploration of space, the student will identify the one event which heralded the beginning of the space age.
4. Given eight characteristics descriptive of the National Aeronautics and Space Administration (NASA), and the National Advisory Committee for Aeronautics (NACA), the student will classify them correctly.

CONTENT

I. Leonardo da Vinci (1452-1519) pioneered studies of flying.
   A. Studied bird flight and drew many pictures of wings which he thought could be attached to the arms and legs of a man so he could fly.
   B. Made drawings of parachutes, propellers, and helicopters.
   C. Never attempted to build any aircraft.

II. Montgolfier brothers of France were the first to build a successful balloon.
   A. Built big balloons filled with hot air in 1783.
   B. Men in baskets floated freely through the air for the first time in history.

III. Henry Giffard built and flew the first successful engine-powered airship.
   A. Cigar-shaped craft.
   B. Steam engine.
   C. Speed of more than six miles an hour.

IV. Orville (1871-1948) and Wilbur (1867-1912) Wright took up gliding as a hobby.
   A. Built gliders and tested them in 1900 and 1901.
   B. Built wind tunnel to test various kinds of wings for aircraft.
   C. Made a light gasoline engine.
   D. Built a gasoline-powered airplane and flew it successfully on December 17, 1903.

V. Wright brothers' first airplanes flew only 12 miles on hand.
   a. Planes had been built that could speed along at more than 100 mph by 1910.
   b. Historical long-distance flight by Charles A. Lindbergh - 1927.
      1. Non-stop flight from New York to Paris.
      2. 3,610 miles across the ocean.
      3. Flight--three and a half hours flying time.
      4. People realized the airplane had "come of age."
   c. James H. Doolittle was twice at speeds close to 300 mph by 1932.
   d. Jet propelled and rocket propelled planes made it possible for man to fly 2-1000 that speed in 1948. (More than 700 mph.)

VI. Nicolaus Copernicus (1473-1543) founded present-day astronomy with his theory that the earth is a moving planet. His theory laid the foundations for the telescopic discoveries of Galileo, the planetary laws of Johannes Kepler, and the gravitation principle of Sir Isaac Newton.
   a. Demonstrated that the sun, not the earth, was the center of the solar system, as earlier astronomers had believed.
   b. He showed that the planets of the solar system, including earth, keep revolving around the sun.

VII. Galileo (1564-1642) made the first practical use of the telescope to discover many new facts about astronomy.
   a. First important observation concerned the moon.
   b. Discovered that the moon was not a smooth sphere shining by its own light.
   c. Observed that the moon's surface was marked by valleys and mountains and that it showed only the light it reflected.
   d. Most sensational discovery was the four bright satellites of Jupiter in 1610.
   e. Firmly upheld the theory of Copernicus that the earth moves around the sun.

VIII. Johannes Kepler (1571-1630) astronomer and mathematician discovered three laws of planetary motion.
   a. Every planet follows an oval-shaped path, or orbit, around the sun, called an ellipse. The sun is located at one focus of the ellipse (not orbit).
   b. An imaginary line from the center of the sun to the center of a planet sweeps out the same area in a given time. Planets move faster when they are closer to the sun.
   c. The time taken by a planet to make one complete trip around the sun is its period.

[illegible]

[illegible]

PRE-ASSESSMENT ANSWER KEY

I. B. F. D. H. C. A. J. I. G. E.

POST-ASSESSMENT ANSWER KEY

I. C. German V-2

II. D. Sputnik I, the first artificial satellite, was launched by Russia.

III.

	NASA	NACA
1.		X
2.	X	
3.	X	
4.		X
5.	X	
6.	X	
7.	X	
8.		X

UNIT II - ROCKETRY AND PROPULSION SYSTEMS

INTRODUCTION

Rockets are not new to mankind; they have been used in warfare and for fireworks displays for hundreds of years.

Scientists believe rockets were invented by the Chinese. Chinese historians described "arrows of flying fire" that were used in war in the year A.D. 1232. Within a few dozen years, rockets were being used in wars in Europe to set fire to enemy fortifications.

A Russian high school teacher, Konstantin E. Tsiolkovsky (1857-1935), was the first to develop the correct theory of rocket action. He described his theory in a paper which was published in 1903. Robert Goddard (1882-1945) began the first scientific experiments with rockets in the United States. Regarded as the "father of the modern rocket," he predicted the use of rockets to explore high altitudes. His paper, "A Method of Reaching Extreme Altitudes," was published in 1919 by the Smithsonian Institution. In 1926, Dr. Goddard built the first liquid-fuel rocket. Four years later he fired a rocket which rose to a height of 610 meters (2,000 feet) at a speed of 800 kilometers (500 miles) an hour. He assisted the United States Government by rocket research in World War II.

Rocket development was paced by the demands of war. The first German V-2 ballistic missile was fired unsuccessfully twice in 1942 before its first successful launching in

October that year. It was to become operational as a field weapon less than two years later, only a few months after the pulse-jet powered V-1 flying bomb was used to bomb London.

A rocket differs from other types of jet-propelled engines because it carries its own oxygen, thus, eliminating the need for oxygen in the air to burn the fuel. A rocket motor, however, uses large amounts of fuel, so most rocket motors can operate only for short periods of time before they run out of fuel.

After the war, many experiments were conducted in the United States with captured German rockets. On December 14, 1946, a V-2 rose to a height of 182 kilometers (114 miles) above the White Sands Proving Ground, New Mexico.

The first large high-altitude sounding rocket designed and built in the United States was known as the Wac Corporal.

In February, 1949, a two-stage rocket was fired by the United States Army. A small Wac Corporal was set in the nose of a V-2 rocket. The V-2 was fired. When it reached an altitude of 32 kilometers (20 miles), the Wac Corporal was fired from the nose of the V-2. The smaller rocket rose to 400 kilometers (250 miles) and reached a speed of 800 kilometers (5,000 miles) per hour.

On July 24, 1950, a modified German V-2, with an Army Wac Corporal second stage was successfully fired from Cape Canaveral. Called "Bumper," the vehicle was launched from the old Pad 3 site, east of Complex 36, and is recorded as

the first Cape launch. (See figure one.) The rocket was 14 meters (47 feet) long, and 2.3 meters (5 feet, 5 inches) in diameter. Weighing 12,805 kilograms (28,229 pounds), its propellants were alcohol and liquid oxygen. It had a thrust of 27,216 kilograms (60,000 pounds) and a range of 354 kilometers (220 miles) maximum.

The Space Age opened on October 4, 1957, when Russia launched the world's first satellite, Sputnik I, with a three-stage rocket.

RATIONALE

The appreciation of the historical aspects incorporated within the study of space awareness allows the learner the opportunity to perceive the linear development of space exploration. The realization that an extreme number of variables has affected the "space thinkers" of the past and present certainly reveals the creative endurance necessary in the study of space exploration. Awareness of the struggle and the accompanying creations enhance the positive reinvorcement involved in learning about space.

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PRE-ASSESSMENT

I. Across from each statement below, check whether it is a characteristic of a Jet or a Rocket.

	Jet	Rocket
1. This engine depends upon the atmosphere for oxygen to release the energy of the fuel.	____	____
2. These engines are designed to fly in the Earth's atmosphere. Oxygen in the air serves as the oxidizer.	____	____
3. Operating in space, these engines do not have the advantage of picking up their propellant as they move on.	____	____
4. This engine carries its own fuel plus oxygen or other chemicals.	____	____
5. An oxidizer must be carried to substitute for the oxygen in the Earth's atmosphere for this engine.	____	____
6. This engine picks up most of its propellant, the air, as it moves along.	____	____
7. This is the only engine capable of propulsion in space.	____	____

II. Place an X in front of the four statements which are characteristics of the new approach to launch operations known as the "Mobile Concept."

____ 1. The space vehicle is assembled and tested in the Vehicle Assembly Building.

____ 2. The Apollo spacecraft consists of a Command Module, a Service Module and a Lunar Module.

____ 3. The space vehicle is erected for checkout, transfer and launch on the Mobile Launcher.

____ 4. The Transporter transfers the space vehicle and Mobile Launcher to the launch site.

____ 5. Skylab is the NASA experimental space station program scheduled to become operational in 1973.

____ 6. The Mobile Service Structure provides external access to the vehicle and spacecraft at the launch site.

____ 7. The Space Shuttle is envisioned as a space transportation system that will economically endure the cost of space operations.

GENERAL OBJECTIVE

To develop a basic understanding of rocketry and propulsion systems.

SPECIFIC OBJECTIVES

1. Given a list of seven characteristics descriptive of jet and rocket engines, the student will classify them correctly.

2. Given five characteristics of liquid and solid fuels, the student will classify them correctly.

3. Given a list containing names of six USSR launch vehicles, in Column A, the student will select the correct descriptive phase for each from a list in Column B.

4. Given six characteristics descriptive of liquid-fuel rockets and solid-fuel rockets, the student will classify them correctly.

5. From a list, the student will select four characteristics of the new approach to launch operations known as the "mobile concept."

CONTENT

I. Review definitions of a rocket, Unit 1.

II. A rocket differs from other types of jet-propelled engines.
   A. Does not need oxygen in the air to burn the fuel because it carries its own oxygen.
   B. Moving through air slows down the flight of a rocket.
   C. Oxygen needed for burning rocket fuel is contained inside the rocket, either in a separate tank or in the fuel itself.
   D. Rocket motor develops more power than any other engine.
   E. Weight is the lowest for each pound of thrust it produces.
   F. Rocket motor uses large amount of fuel - must operate

[redacted] Put a check [redacted] of each [redacted] they can not [redacted]

[redacted]	[redacted]
1. [redacted]	1. [redacted]
2. [redacted]	2. [redacted]
3. [redacted]	3. [redacted]

[redacted]

a. [redacted]
b. [redacted]
c. [redacted]
d. [redacted]
e. [redacted]
f. [redacted]
g. [redacted]

[redacted]

a. [redacted]
b. [redacted]
c. [redacted]
d. [redacted]
e. [redacted]
f. [redacted]

[illegible]

[redacted]

The Fourth Ring of Saturn (color) 26 minutes
Powering Apollo (color) 4:45 minutes
The Service Module (color) 4 minutes
Saturn Third Stage (color) 5:30 minutes

POST ASSESSMENT

I. Across from each statement, check whether it is a characteristic of solid fuel or liquid fuel.

	Solid Fuel	Liquid Fuel
1. This fuel is made by mixing rubber, resin, or asphalt with a compound containing oxygen.	_____	_____
2. This combination could consist of oxygen in liquid form and alcohol.	_____	_____
3. This combination could consist of nitric acid and aniline.	_____	_____
4. Some combinations could start burning on contact while others must be ignited.	_____	_____
5. This type fuel is composed of nitrocellulose and nitroglycerine.	_____	_____

II. In the space before each word in Column B, print the one letter of the statement in Column A which best describes that word.

COLUMN A	COLUMN B
A. This vehicle launched Apollo 7, the first manned Apollo Earth-orbital mission.	_____ 1. Delta
B. The first U.S. rocket system to utilize oxygen and liquid hydrogen.	_____ 2. Redstone
C. Considered the workhorse of NASA vehicles, this rocket launched the first Orbiting Solar Observatory.	_____ 3. Atlas
D. This is the U.S. largest and most powerful launch vehicle.	_____ 4. Titan II
E. This vehicle can be launched from underground (silo) sites.	_____ 5. Saturn IB
F. This vehicle is an Air Force ICBM with a top speed of 27,200 kilograms (17,000 miles) per hour.	_____ 6. Saturn V
G. The smallest of the basic launch vehicles this one is the only U.S.	_____ 7. Scout
	_____ 8. Centaur

launch vehicle with solid propellants exclusively.

H. Developed by German, this was the first practical vehicle driven by rocket power.

I. This U.S. Navy vehicle is an example of a rocket built and used solely as a research vehicle.

J. This vehicle was used to launch the first two Americans to go into space, Shepard and Grissom.

III. Across from each statement, check whether it is a characteristic of a liquid-fuel rocket or a solid-fuel rocket.

	Liquid-Fuel Rocket	Solid-Fuel Rocket
1. This rocket usually carries two kinds of fuel stored in separate tanks.	____	____
2. There are two main parts to the motor of this rocket: (1) A combustion chamber and (2) A nozzle from which the burned gases are exhausted.	____	____
3. This type rocket was tested successfully in 1926 by Dr. Robert H. Goddard.	____	____
4. The motor of this rocket has four main parts: (1) A combustion chamber, (2) A fuel injector, (3) An exhaust nozzle and (4) A cooling system.	____	____
5. Most rockets of this type are high-altitude rockets.	____	____
6. These rockets are similar to those used in fireworks displays.	____	____

PRE-ASSESSMENT ANSWER KEY

I. 1. Jet
2. Jet
3. Rocket
4. Rocket
5. Rocket
6. Jet
7. Rocket

II. 1, 3, 4, 6

POST ASSESSMENT ANSWER KEY

I. 1. Solid Fuel
2. Liquid Fuel
3. Liquid Fuel
4. Liquid Fuel
5. Solid Fuel

II. 1. C
2. J
3. E
4. F
5. A
6. D
7. G
8. B

III. 1. Liquid-fuel rocket
2. Solid-fuel rocket
3. Liquid-fuel rocket
4. Liquid-fuel rocket
5. Liquid-fuel rocket
6. Solid-fuel rocket

UNIT III - UNMANNED AND MANNED SPACE FLIGHTS

INTRODUCTION

In 1955, the United States announced to the world that it would launch several artificial Earth satellites as part of its contribution to the I.G.Y. program. Soon after, Russian scientists stated that their nation would carry out a similar plan. Scientists and missile engineers had long recommended such a program as an extension of their rocket research into the upper air. At last, the world learned in 1955, the long-discussed exploration of space was to be attempted.

The first successful Earth satellite was Sputnik I, launched by Russia on October 4, 1957. It was a metal sphere, weighing 83 kilograms (184 pounds), and it carried a radio transmitter and devices for measuring temperature and pressure inside the satellite. A much larger object, Sputnik II, was placed in orbit within a month, on November 3, 1957. This second satellite weighed over 0.453 metric tons (half a ton) and carried instruments for measuring cosmic rays, ultra-violet and x-ray radiation, and a small passenger compartment in which a dog, Laika, remained alive for a week.

The first American satellite, Explorer I, was launched on January 31, 1958. Though only 14 kilograms (30.8 pounds), it was packed with many minature instruments for measuring radiation and temperature in space.

Of all the types of artificial satellites, the communi-cations satellites may have the most direct impact on everyday

life. These satellites have provided the means for developing an unlimited global communications system. Television depends heavily on transmission via satellite.

Score is considered to be the first satellite of this type, though strictly, it was not a communications satellite. Score and Courier, another of the early communications satellites, were both delayed repeater satellites; they received information from one part of the Earth and stored the message on a tape recorder for later transmission on command. President Eisenhower's Christmas message to the world had been recorded prior to launch on Score and later was transmitted to Earth. This was the first "voice from space." This type of a satellite was abandoned in favor of instantaneous repeater satellites.

Echo I, the first true communications satellite is called a passive satellite because it simply is used to bounce a signal received from one point on the Earth to another point.

Telstar and Relay are active repeater satellites because they receive, amplify, and rebroadcast messages. These satellite projects, launched in medium-altitude orbits, were initiated by private enterprise. Telestar provided the first transmission of live television across the Atlantic Ocean.

Syncom, another active repeater satellite, was the first satellite to revolve in a synchronous orbit. In a synchronous orbit, a satellite revolves at a rate which will keep it above a fixed point at all times, making the satellite appear

to be stationary. The successful performance of the Syncom satellites led to the founding of the Communications Satellite Corporation which patterned its first commercially operational communications satellite, Early Bird, after Syncom.

The remarkable success of the early satellites led steadily toward the inevitable transition from unmanned to manned flights.

Nineteen hundred sixty-one was the year in which man first left his planet for ventures into the unknown environment beyond. First honors for space flight went to Russian Air Force Major Yuri Gagarin.

On May 5, 1961, American astronaut Alan B. Shepard entered a Mercury spacecraft at Cape Canaveral, Florida, and propelled by a Redstone rocket, roared upward and southward to a maximum height of 185 kilometers (115 miles). Fifteen minutes later, he dropped into the Atlantic Ocean where he and his Mercury capsule were recovered by waiting ships. The space age was indeed a reality.

RATIONALE

Man has always longed to travel out into space--to visit other planets, to explore the moon, and to determine the conditions that exist in the regions beyond the Earth's atmosphere. A combination of unmanned and manned space exploration is necessary for man to pursue these goals. A different type of situation arises when launching satellites that are manned as compared to the launching of unmanned satellites.

The learner suddenly becomes involved in an entity that demands an understanding of the variables affecting life in space. What are the factors that differentiate manned from unmanned space flights? Recognizing the psychological and physiological barriers encountered by man in traveling into space can offer a revealing picture of the dynamic human forces affiliated with manned space flights.

[illegible]

3. In the space provided next to Column A, write the number of the statement from Column B which best describes that term.

Column A	Column B
1. [illegible]	____ A. [illegible]
2. [illegible]	____ B. [illegible]
3. [illegible]	____ C. [illegible]
4. [illegible]	____ D. [illegible]
5. [illegible]	____ E. [illegible]
6. [illegible]	____ F. [illegible]
7. [illegible]	____ G. [illegible]
8. [illegible]	____ H. [illegible]
9. [illegible]	____ I. [illegible]
10. [illegible]	____ J. [illegible]
11. [illegible]	
12. [illegible]	

[redacted]

1. [redacted]

2. [redacted]

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1. [redacted]

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1. [redacted]
   a. [redacted]
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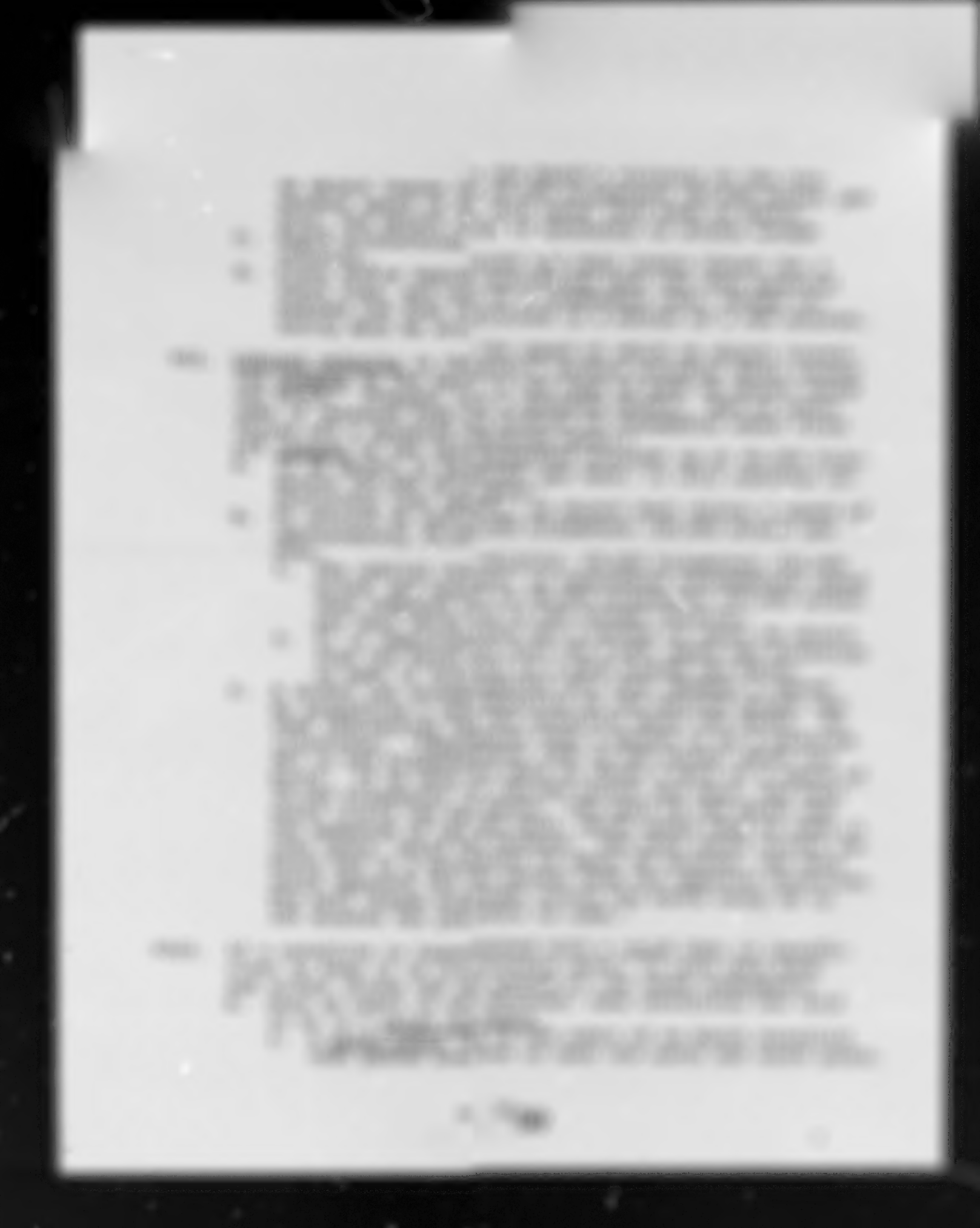
      i. [redacted]
      ii. [redacted]



A. The Surveyor's were launched from May 30, 1966 to January 7, 1968.
B. The first Surveyors were primarily picture-taking spacecraft.
C. Later Surveyors added experiments in soil mechanics and analyzed surface composition.
D. The weights of the Surveyors varied between 270 and 286 kilograms (596 and 630 pounds) at lunar landing.

XVIII. The planetary probe program of the Jet Propulsion Laboratory in Pasadena was called Mariner.
A. The first, Mariner I, was launched July 22, 1962, but had to be destroyed by the Cape Kennedy Safety Officer when it veered off course.
B. Mariner II was successfully launched toward Venus on August 27, 1962. Mariner II passed within 34,556 kilometers (21,598 miles) of Venus.
C. Mariners III and IV were Mars probes.
D. On October 19, 1967, Mariner V flew past Venus some 10,151 kilometers (6,300 miles) from the planet's center.
E. Mariners six and seven were put on their Martian course by Atlas Centaur launch vehicle which lifted off at 8:29 p.m. EST February 24 and 5:22 p.m. March 27. Number six took 156 days to make the outward trip; number seven, 130 days. The difference in trip time is accounted for by the orbital motion of Earth and Mars. (See figure two.)
F. Mariner Mars 1971 Program was the first U.S. mission to orbit another planet.
1. A failure of the second stage of the Atlas Centaur in May prevented Mariner 8 from achieving trajectory to Mars.
2. Mariner 9 was successfully launched on May 30, 1971, and encountered Mars on November 13, 1971.
3. Objective of Mariner 9 was to explore Mars for at least 90 days in orbit, to map about 70 percent of the planet's surface and to view selected areas during dynamic changes on Mars. (See figure three.)

XIX. The U.S. Pioneer space probes flew toward the Moon; they were instrumented to explore space between the Earth and Moon (called cislunar space).
A. Five Pioneers were launched during 1958-60.
1. The Pioneer that came closest to the Moon was Pioneer IV (launched March 3, 1959), which passed 59,680 kilometers (37,300 miles) from the Moon on its way into orbit about the Sun.
2. The first five, called the early Pioneers, contributed greatly to man's understanding of the

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Earth's Van Allen Region and the solar wind.

3. The last of the earlier group, Pioneer V, was launched March 11, 1960.
   a. Radio communication was maintained with Pioneer V until June 26, 1960.
   b. Pioneer V confirmed the existence of previously theorized interplanetary magnetic fields.

B. The first of the new Pioneers was Pioneer VI which was launched December 16, 1965 into an orbit between Earth and Venus.

C. On August 17, 1966, Pioneer VII was launched into an orbit between Earth and Mars.

D. Pioneer VIII was launched December 13, 1967.

E. Pioneer 9 was launched in 1968 with the mission of acquiring additional data on solar plasma and energetic particles and magnetic fields propagated by the Sun towards the Earth.

F. A three-stage Atlas-Centaur launch vehicle put Pioneer 10 on a near perfect Jupiter-bound trajectory at 8:49 p.m. EST on March 2, 1972, in a launch from Cape Kennedy, Florida. (See figure four.)
   1. Pioneer 10 is the first spacecraft to be placed on a trajectory to escape from a solar system into interstellar space.
   2. Experiments on board Pioneer 10 will measure numbers and characteristics of asteroids and will make a variety of measurements of Jupiter's atmosphere, the planet's heat balance (related to its presumed internal energy source), its magnetic fields and radiation belts, and other characteristics.
   3. Pioneer 10 is planned to fly by Jupiter on December 3, 1973. After passing Jupiter, it may well continue transmitting data to Earth on the Sun's atmosphere and interstellar phenomena out to the orbit of Uranus, more than three billion kilometers (two billion miles) away.

G. The Pioneer Project is managed by the National Aeronautics and Space Administration's Ames Research Center, Moffett Field, California.

XX. Once NASA proved the feasibility of the synchronous communication satellite, the technology was used by a commercial enterprise called the Communications Satellite Corporation (COMSAT).

A. COMSAT was created by an act of Congress on August 30, 1962, and was assigned two major tasks.
   1. One task was to establish an operational system of communication satellites.
   2. The other task was to enlist the support of

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foreign governments in setting up international service.

B. COMSAT's task of enlisting the support of foreign governments in setting up international service was accomplished through organization of the International Telecommunications Consortium (INTELSAT) which now includes more than 70 member countries.
   1. The Consortium owns the communication satellites, called INTELSATs.
   2. Regular transoceanic service commenced in 1967, with synchronous communication satellites stationed over the Atlantic and Pacific oceans.
   3. The Intelsats are all geostationary spacecraft carrying small rocket engines that move them to and keep them at selected spots over the Equator.
   4. There are now four generations of Intelsats, with a trend toward bigger and better satellites with each new generation.
   5. Compared with the 1965 Intelsat I, also called Early Bird, which was not much bigger than a waste basket the 1970 Intelsat IVs, which consists of satellites 0.5368 meters (17.6 feet) high, represent an important advance in terrestrial communications.

C. NASA's role is to provide launch and tracking services for COMSAT on a reimbursable basis and pursue new ideas in the technology of communication satellites.

D. In comparison, NASA's efforts are directed primarily toward development of new spacecraft and sensors, while COMSAT is concerned more with ground operations and the practical applications of the data acquired by the satellites.

XXI. Scientific satellites carry instruments to measure magnetic fields, space radiation, the Sun, etc.

A. The Explorer series of scientific satellites began before NASA was created.
   1. Army Explorer I, the first of the long series (37), was the first U.S. satellite, and was launched on January 31, 1958.
   2. Explorers II, III, and IV were also Army satellites. All other Explorers were launched by NASA.
   3. Explorers II and V failed.
   4. Explorer satellites varied widely in design and purpose.

B. The Orbiting Solar Observatory (OSO) is the smallest of the observatory class of satellites and carry fewer instruments.
   1. With four OSOs in the series, the weights vary between 204 and 294 kilograms (450 and 650 pounds).
   2. Some OSO experiments are located in the spinning

wheel section, while others are in the wall which parents ceremoniously at the bar.

C. The orbiting Geophysical Observatories (OGOs) consisted of a family of five which were built by NASA.
   1. OGOs are large and relatively sophisticated.
   2. With weights between 454 and 545 kilograms (1,000 to 1,200 pounds), OGOs were designed to carry twenty or more experiments in the fields of geophysics, space physics, and astronomy.

D. The orbiting Astronomical Observatories (OAOs) are large, sophisticated satellites designed to study the stars in the ultraviolet region of the spectrum and to carry out associated experiments in space science.
   1. The OAOs are programmed to search for and follow certain guide stars.
   2. Once the telescope locks onto a guide star, the star tracker sends its coordinates to guidance and control systems.
   3. OAO 2, launched April 8, 1968, weighed 1770 kilograms (3,900 pounds).

E. The Biosatellite family of recoverable scientific satellites was designed to study the effects on living things of such phenomena as weightlessness, weightlessness combined with radiation, and removal from the diurnal (day-night) cycle on Earth.
   1. Biosatellite I, launched December 14, 1966, could not be brought down as scheduled because of retrorocket failure. Efforts to locate the craft during its anticipated manual recovery on February 14, 1967, were unsuccessful.
   2. Biosatellite II carried frog eggs, microorganisms, plants, and insects on an orbital flight that lasted about two days.
   3. NASA launched Biosatellite II from Cape Kennedy, Florida, on September 7, 1967. About two days later, ground controllers ordered the satellite to fire retrorockets, slowing it so that it fell out of orbit toward the Earth. As it parachuted down over the Pacific Ocean west Hawaii, the spacecraft was retrieved in the air by a United States Air Force plane.

XVII. NASA's Earth Resources Technology Satellite (ERTS) program began at Goddard Space Flight Center in 1964.
A. Four program objectives were identified.
   1. To define those practical problems where space technology can make beneficial contributions.
   2. To conduct research in sensors and establish their utilities in Earth observations.
   3. To develop and qualify sensors and spacecraft.
   4. To develop handling and processing techniques for

[illegible]

4. When the human body is suddenly accelerated or decelerated, the body is affected.
   a. Acceleration exists as the space vehicle starts to rise from the Earth.
   b. Deceleration exists as the vehicle attempts to return to Earth and must be slowed down before landing.
5. In the spacecraft, the position and design of the astronaut's couch helps him withstand the forces of acceleration and deceleration.

V. Food for the astronauts must be preserved and specially prepared for trips in space.
   A. The food must be prepared so that it can be consumed by astronauts who are weightless.
   B. The food must be consumed in an environment where everything is weightless, including the food.
   C. Menu items range from cereals, orange juice, and toast, to meats, eggs, fish and fruit salad.
   D. Solid foods are dehydrated and packed in bite-sized portions, in tubes, or as concentrates enclosed in plastic bags in which water may be added with a water gun.

VI. Astronauts must be careful to prevent food particles or water droplets from escaping.
   A. In a weightlessness condition, such particles would drift in the cabin.
   B. Drifting food particles and water droplets could result in problems with sensitive equipment.

VII. A weightless condition is present in the absence of gravity.
   A. A person stepping on a scale to weigh himself could find that he weighs 68 kilograms (150 pounds).
      1. The weight of 68 kilograms (150 pounds) is the amount of the pull of gravity of the Earth on him.
      2. The pull of gravity gives him weight.
      3. He is being pulled toward the center of the Earth.
      4. Remove the pull of gravity and he becomes weightless.
   B. Without gravity a person still has mass.
      1. Mass is the actual amount of matter of which a person is composed.
      2. Mass exists without gravity but it does not weigh anything.
      3. In distant space, one is too far from Earth to be affected by gravity very much.
   C. Theories of some scientists differ as to the way a person will feel when he is weightless for a long period of time.
      1. In a weightless condition, the sensation will be

very much like seasickness.
2. The person in a weightless condition will have a sense of well-being.
3. The person in a weightless condition will have a sense of falling constantly.

D. Weightlessness has not proven to be a problem for astronauts.

VIII. NASA's manned space flight program was conceived in three steps or projects, Mercury, Gemini and Apollo.

IX. Project Mercury became an official program of NASA on November 26, 1958.

A. Originally, Project Mercury was assigned only two broad missions by NASA--first, to investigate man's ability to survive and perform in the space environment; and second, to develop the basic space technology and hardware for manned space flight programs to come.

B. The one-man Mercury spacecraft was shaped somewhat like a bell (truncated cone). It was 2.9 meters (9.5 feet) high and 1.8 meters (6 feet) across at the base. It weighed approximately 1,928 kilograms (4,250 pounds) at lift-off and 1,089 kilograms (2,400 pounds) at recovery.

C. Two boosters were chosen--the Army's Redstone with 35,380 kilograms (78,000 pounds) of thrust and the Air Force's Atlas with 166,471 kilograms (367,000 pounds) of thrust--for suborbital and orbital flights, respectively.

D. A space milestone was reached in the Mercury program when on February 20, 1962, Astronaut John H. Glenn, Jr., the first American in orbit, completed three circuits in Friendship 7.

E. On May 15-16, 1963, Astronaut L. Gordon Cooper, Jr., completed a 22-orbit mission of 34½ hours in Faith 7, triumphantly concluding the flight phase of Project Mercury which consisted of four manned orbital flights.

F. Among the significant aerospace medical information derived from Mercury were the following:
1. Consumption of food and beverages and sleeping during space flight were proved possible.
2. The radiation dose received by the astronauts was considered medically insignificant.
3. All measured physiological functions remained within anticipated ranges throughout all flights. There was no significant degradation of pilot function attributable to space flight.
4. There was no evidence of abnormal sensory, psychiatric, or psychological responses to space flight.

G. Other notable accomplishments of Project Mercury were the following:

1. Development of a NASA management system that could carry out more advanced manned space flight ventures.
2. Exploration of the fundamentals of spacecraft reentry.
3. Starting a family of launch vehicles from existing rockets that led to new booster designs.
4. Setting up of an Earth-girdling space tracking system that was later modified for the Gemini and Apollo projects.
5. Training of a pool of astronauts that could be augmented to meet the requirements of future space exploration programs.

X. Project Gemini was named after the constellation Gemini (Twins).
   A. NASA decided to follow the Mercury's basic "capsule" design for Gemini spacecraft, saving time and engineering efforts. But the two-man craft was wider, taller, and more than twice as heavy as the Mercury.
   B. Since Mercury's Redstone and Atlas boosters lacked the power to orbit the heavier two-man craft, a modified version of the military Titan II became the Gemini Launch Vehicle (GLV), with a lift-off thrust of 195,048 kilograms (430,000 pounds).
   C. Project Gemini extended orbital missions up to two weeks at a time and developed the techniques for orbital rendezvous and docking, in which two space vehicles are maneuvered close together and finally joined.
   D. From the first Gemini unmanned flight on April 8, 1964, to the final manned flight ending November 15, 1966, Gemini flight time totaled 974 hours, 37 minutes, and 42 seconds. Of this, 969 hours, 51 minutes, and 26 seconds were manned.
   E. The highest altitude reached by the manned Gemini spacecraft was 1,373 kilometers (853 miles) during the Gemini XI mission. This set a world's record.
   F. Orbital rendezvous was accomplished 10 times and docking was accomplished 9 times during Gemini missions. Docking, first accomplished on March 16, 1966, in the Gemini 8 experiment, is another Gemini first in space.
   G. Gemini astronauts spent a total of 12 hours and 12 minutes without the protection of their spacecraft in "space-walk" and other activities.
   H. Gemini astronauts took photographs of Earth and its cloud cover, providing a new wealth of information for geographers, meteorologists, and oceanographers. There photographs indicated that sensing from orbit may be a good way to locate and observe Earth's resources: water, minerals, oil and others. A new

atlas is based on photographs of Earth taken by the astronauts during Gemini flights.

I. Gemini experiments validated life-support techniques, equipment, and concepts for future space missions. The experiments suggested that man could safely conduct operations in space for as long as 30 days.

XI. Apollo, the largest and most complex of the manned space flight programs had as its goal the landing of astronauts on the Moon and their safe return to Earth. A detailed discussion of Project Apollo follows in Unit IV.

SPACE AWARENESS VOCABULARY

Project Mercury	Sputnik	Spectrograph
Project Gemini	Parabola	Spectrum
Project Apollo	Radius	Solar system
Orbital velocity	Hyperbola	Apogee
Escape velocity	Radiation	Rendezvous
Meteoroid	Van Allen Belt	Perigee
Weightlessness	Deceleration	Probe
Acceleration	ITOS	NOAA
COMSAT	INTELSAT	ERTS

SUGGESTIONS FOR THE TEACHER

It is most important that adults begin the study of a new unit with interest and enthusiasm. A hurriedly given directive from the teacher that a particular NASA publication should be read for the next class meeting will rarely arouse the feeling that what is coming is sure to be fascinating and important.

A dramatic situation can be found which will be of general appeal to the class and which will suggest the theme of the unit to be studied. A comparison of two films might serve the purpose. Show a film which highlights unmanned flight and a film illustrating manned flight. A film on unmanned flight which is rated excellent for adult students is the The First Soft Step. This black and white 29 minute film provides a detailed look at the overall mission and accomplishments of the Surveyor program to soft-land a picture-taking craft on the surface of the Moon. Questions are skillfully asked and answered in language that the lay adult can understand. Our Man In Space is a 16:30 minute color film which could provide the manned flight picture. This NASA film provides excellent coverage and photography of Shepard's flight, offers a good suspense-type buildup, and is rated excellent for adult education.

Both of these films can be introduced, shown, and discussed very easily in the same class period. In your introduction of the films, drive home the fact that the students will be

studying unmanned and manned flight, purposes and goals of each, and why unmanned flight had to precede manned flight.

For alternative interest stimulating activities, consider having your class design and equip an imaginary spacecraft with all of the systems necessary for a manned mission in space. You may also want to display models or pictures of Mercury, Gemini and Apollo capsules and discuss the reasons for the differences in them. Have your class organize a bulletin board of news and pictures concerning launchings and spacecraft.

Following the unit introduction, you should refer to the overall suggestions to the teacher at the beginning of the guide as you progress through the unit.

Refer to the appendix for laboratory-type activities for this unit and use them as facilities and circumstances permit in your particular situation. The group of adults you are working with will also influence the type of activities you select.

ILLUSTRATIVE RESOURCES

NASA Publications:

EP-40	Communications Satellites
EP-27	Meteorological Satellites
EP-57	American in Space/The First Decade-Man in Space
NF-27	Living in Space
EP-54	NASA Spacecraft
NF-3	Biosatellite II
NF-26	A Report from Mariner IV
NF-21	Pioneer
S-5	Weightlessness
S-7	Orbits and Revolutions
NF-8	Mariner II Reports
EP-53	Putting Satellites to Work
EP-52	Exploring the Moon and Planets
EP-84	Satellites at Work
NF-9	Manned Space Flight: Projects Mercury and Gemini
NASA	America's Spaceport
PAFB	

Textbooks:

Wolfe, Battan, Fleming, Hawkins, and Skornik, Earth and Space Science, D. C. Heath and Company, Boston

MacCracken, Decker, Read and Yarian, Scientists Solve Problems, L. W. Singer Company, Second Edition

Brandwein, Bock, Strahler, Hollingworth and Brennan, The World of Matter-Energy, Harcourt, Brace and World, Inc.

Broadbeck, Beck, Strahler, Hollingsworth and Brennan. The World of Living Things. Vermont, Bruce and World, Inc.

Films:

The Four Days of Gemini IV (color) 28 minutes
The Flight of Sigma 7 (color) 27 minutes
Gemini XII Mission (color) 25 minutes
The Legacy of Gemini (color) 27:40 minutes
Ariel II (color) 26:30 minutes
The First Soft Step (black and white) 29 minutes
The Mastery of Space (color) 58 minutes
Astronaut Training (color) 7:30 minutes
The Space Suits (color) 5 minutes
Our Man in Space (color) 16:30 minutes
Flight of Freedom Seven (color) 10 minutes
Friendship 7 (color) 58 minutes

POST ASSESSMENT

1. To the right of each of the following statements, check whether it applies to Project Mercury, Project Gemini, or Project Apollo.

	Mercury	Gemini	Apollo
1. Experimentation during this project validated life support techniques, equipment, and concepts for future space missions.	____	____	____
2. This was the largest of NASA's manned space flight programs.	____	____	____
3. This project extended orbital missions up to two weeks at a time and developed the techniques for orbital rendezvous and docking.	____	____	____
4. The mission of this project was to investigate man's ability to survive and perform in the space environment and to develop the basic space technology and hardware for manned space flight programs to come.	____	____	____
5. Astronaut L. Gordon Cooper concluded the flight phase of this project when he completed a 22-orbit mission of 34½ hours.	____	____	____
6. During this project, astronauts performed the first "space walk" activity of the U.S. space program.	____	____	____

PRE-ASSESSMENT ANSWER KEY

1.

POST-ASSESSMENT ANSWER KEY

1. Uranium
2. Plutonium
3. Uranium
4. Mercury
5. Mercury
6. Uranium

[illegible]

1. [illegible]

   a. [illegible]
   b. [illegible]
   c. [illegible]
   d. [illegible]
   e. [illegible]
   f. [illegible]
   g. [illegible]
   h. [illegible]
   i. [illegible]
   j. [illegible]

[illegible]

1. [illegible]

[illegible]

1. [illegible]

2. [illegible]

3. [illegible]

[illegible]

1. [illegible]

2. [illegible]

3. [illegible]

hour. This is the speed on return to Earth from a lunar mission.

3. In the atmosphere, the Apollo crew was able to guide the spacecraft to a selected landing area.
4. The command module was cone shaped, 3.5 meters (11 feet, 5 inches) high, and had a base diameter of 3.9 meters (12 feet, 10 inches).

C. The service module was equipped with rocket engines and fuel supplies which enabled the astronauts to propel their craft into and out of lunar orbit and to change their course and speed in space.
   1. The service module was jettisoned just before the Apollo entered Earth's atmosphere.
   2. The service module was 7.5 meters (24 feet, 7 inches) high, and had a base diameter of 3.0 meters (12 feet, 10 inches).

D. The lunar module (LM) was the "space ferry" which transported two Apollo astronauts down to the Moon, carried them from the Moon's surface into lunar orbit, and rendezvoused with the Apollo command and service modules in lunar orbit.
   1. Among the LM's equipment were rockets for slowing down before landing on the Moon and for maneuvering in orbit, and four spiderlike legs that were extended to support the spacecraft on the Moon's surface.
   2. The legs and landing rockets were left on the Moon.
   3. After the two-man crew of the LM returned to the command module, the LM was either jettisoned and fired into a lunar orbit that would prevent its interfering with future missions, or it was cast off and driven from orbit into the lunar surface, thus, making a last contribution to science. (NOTE: See Apollo 12, Unit V).
   4. The lunar module was 7 meters (22 feet, 11 inches) high and had a base diameter of 3.0 meters (13 feet).

E. Designed for as long as 78 hours of operation, the LRV had a top speed of 13 kilometers (8 miles) per hour and a cruising speed of 10 kilometers (6 miles) per hour. Its range was approximately 480 kilometers (65 miles) and payload capacity was 500 kilograms (1,100 pounds).

F. The LRV was carried to the Moon in the cargo compartment of the descent stage of the lunar module in a folded position.

X. The return trip to Earth began with the two astronauts entering their LM and blasting off, using the LM's lower section as a launch pad.

A. The astronauts entered orbit and steered the LM to connect with the command module (rendezvous and dock).
B. After the two astronauts entered the command module, they turned the spacecraft around, and jettisoned the LM.
C. At this point they fired a rocket in the service module to boost the parent craft out of lunar orbit toward Earth.

XI. One of the most critical phases of the return to Earth for Apollo was atmosphere entry.
A. The astronauts checked their course by sighting the Earth, the Moon, and the Stars, and they received information from tracking stations on Earth.
B. At a speed of 40,000 kilometers (25,000 miles) per hour, which is the Earth-approach velocity of a spacecraft returning from a lunar mission, the astronauts had to follow an extremely precise course called an entry corridor to avoid burning up or bouncing back in space.
C. The crew corrected the flight path by operating rockets in the service module to adjust Apollo's course properly and head for the atmosphere at the proper altitude and angle.
D. When they reached the entry corridor, the astronauts jettisoned the service module, turned the command module around, and began their reentry.
E. As they descended, friction with the air slowed the module and made the heat shield glow.
F. The astronauts controlled the descending module and directed it toward the landing area.
G. After the searing heat and heavy deceleration forces of atmosphere entry were passed, the spacecraft released large parachutes which stabilized and slowed the spacecraft for landing. The three astronauts floated down into the Pacific Ocean. (See figure nine.)
H. Recovery forces which were deployed in the expected landing area picked up the spacecraft and the crew.

SPACE AWARENESS VOCABULARY

Payload	Space Medicine	Meteor
Command Module	Astronaut	Meteoroid
Service Module	Posture sense	Meteorite
Lunar Module	Quarantine	Re-entry
Jettison	Debrief	Space Myopia
Friction	Lunar	Parking Orbit

SUGGESTIONS FOR THE TEACHER

It would be well to introduce this unit with an explanation of the fact that the student will not encounter a detailed account

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of Project Apollo in this unit but rather an account of a typical Apollo mission. A detailed account of each Apollo mission follows in Unit V.

A NASA film, Apollo Lunar Mission Profile, should be considered as an aid in the introduction of this unit. This is a 31 minute, color film, which presents a step-by-step analysis of what is involved in an Apollo flight. Rated excellent for adult education, the film offers a good explanation of the precise timing that was essential for the success of Apollo.

In lieu of, or in conjunction with the film, you may distribute the NASA educational publication NF-40/11-67 entitled Journey to the Moon. This is an excellent format of pictures and explanations of the entire lunar journey in simplified terms, from launch to recovery.

In the course of the unit, you may consider a discussion of the various ways of preserving food. Have the students collect items that could be found in the home demonstrating various ways of preserving food. Which of the various processes will be most advantageous to space flight? Include an examination of the processes of refrigeration, drying, freeze-drying, freezing and canning.

Have students make reports on the methods of waste disposal in the space program (Reference - NASA Facts, NF-27, Living in Space).

Introduce the students to various kinds of water purification systems. Some students might be able to make models of some of these systems. How might one of these be used in space?

Have the students make a study of how valuable exercise is to the human system. What happens to living things without exercise? What are isometric exercises? Have the students do some isometric exercises. Why are these exercises good for astronauts to do?

In addition to these suggestions, refer to the overall suggestions to the teacher.

Refer to the appendix for other activities and use them as you deem appropriate for the group of adults you are working with.

ILLUSTRATIVE RESOURCES

NASA Publications:
NF-23 Manned Space Flight: Apollo
NF-27 Living in Space
NF-40 Journey to the Moon
NF-41 Food for Space Flight

MF-13 Saturn V
S-4 The Countdown
S-5 Weightlessness

Textbooks:

Wolfe, Battan, Fleming, Hawkins, and Skornik, Earth and Space Science, D. C. Heath and Company, Boston.

MacCracken, Decker, Read and Yarian, Scientists Solve Problems, L. W. Singer Company, Second Edition.

Brandwein, Beck, Strahler, Hollingworth and Brennan, The World of Matter-Energy, Harcourt, Brace and World, Inc.

Films:

Apollo IV: The First Giant Step (color) 11 minutes
Lunar Receiving Lab (color) 7:45 minutes
Apollo Lunar Mission Update (color) 17 minutes
Apollo Lunar Mission Profile (color) 31 minutes
Apollo Mission Highlights (color) 5 minutes
The Lunar Module (color) 5 minutes

POST-ASSESSMENT

I. To the right of each statement, check whether it is a characteristic of the Command Module, Service Module, or Lunar Module.

	Command Module	Service Module	Lunar Module
1. Contained supplies, fuel and rocket engine.	___	___	___
2. This was similar to a crew compartment of a commercial jet airliner.	___	___	___
3. This was the only section of the three-section spacecraft which returned to Earth.	___	___	___
4. This carried two of the three Apollo astronauts to the Moon's surface and landed.	___	___	___
5. This was jettisoned after the two astronauts rejoined the third one in the parent craft.	___	___	___

	Command Module	Service Module	Lunar Module
6. This had to be constructed to withstand tremendous deceleration forces and intense heat.	____	____	____
7. The module which contained rocket engine which enabled the astronauts to maneuver into and out of lunar orbit and alter their course and speed in space.	____	____	____

PRE-ASSESSMENT ANSWER KEY

1. A. To land astronauts on the Moon.
   C. To explore the lunar surface.
   E. To conduct scientific experiments on the Moon to furnish scientific data on Earth.
   F. To obtain lunar samples.
   G. To return astronauts safely to the Earth.

POST-ASSESSMENT ANSWER KEY

2. 1. Service Module
   2. Command Module
   3. Command Module
   4. Lunar Module
   5. Lunar Module
   6. Command Module
   7. Service Module

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

1. In this agency brochure must Seattle provide to include to service the [illegible] Tacoma [illegible] Olympia Grade include a which Washington Youth provided.

[illegible] A	[illegible] A
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

2. Many Access Straight at Use Inside Address Commissioner.

3. Any environmental requirement be the our? Have it for Wash Are the Health at Local Civil planning Clean Lighting.

4. May civil citizen of the Local Wash Act Department to Civil Address.

5. Water recreational Coal Office Trade Wash a Trade Washington to Civil Address Local Office Address Public.

6. Civil and the Civil Applicable research to the Address Accounting.

7. Development of the Use civil research Department Clean Lighting. Civil Attorney and Address Accounting to the Wash.

8. Civil Attorney Address the Civil Straight of the Representatives to Public Address Commissioner. Use Attorney Act the Use Civil Clean Lighting Agency to to Civil Address of Address Recreation.

9. Civil Attorney the Civil research Trade Commission the and the Civil Address Straight of the Income Address to and Public Public.

10. Civil and the research assessment Department Business to Straight.

11. Civil the to Attorney of to Student Straight of a Civil Civil Administrative Trade and Health to the Wash and Civil.

12. Civil and the Civil Address Department Department Business to Straight Act Civil the Trade Address research Local Public Attorney.

13. The Commissioner of the the Administrative Act. Trade of to Administrative Trade Civil Civil Public. Accounting Trade Commissioner. and Lighting Trade to to Student Administrative to Civil to Act and Wash Civil Trade the Wash.

14. Civil any the Wash Straight Trade Student to the Wash Address Civil.

15. Civil the the Civil research Department Wash to Administrative Civil Public.

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seismometer for 55 minutes, building up to a peak at the 8-minute mark and then slowly declining.

E. The Apollo 12 crew was picked up in the Pacific recovery area on November 24, 1969.

XII. Apollo 13, with astronauts James Lovell, Fred Haise and Jack Swigert aboard, was launched by a Saturn V on April 11, 1970.

A. Astronaut Jack Swigert, a member of the Apollo 13 backup crew, replaced Thomas K. Mattingly on the prime crew after Mattingly was exposed to measles.

B. When a liquid oxygen tank (LOX) exploded in the service module the explosion wiped out the CSM's main supply of life-sustaining oxygen and power.

C. The LM became the lifeboat after the CSM became a partial wreck, drifting in space.

D. Mission Control aborted the mission enroute to the Moon and ordered the crew into the LM for return to Earth. A safe landing was effected in the Pacific on April 17, 1970. (See figure 12.)

E. Even though classes as a failure, Apollo 13 produced much significant new information which prompted the title "Successful Failure."

XIII. Apollo 14 embodied modifications recommended as a result of the abortive Apollo 13 mission.

A. A Saturn V vehicle launched Apollo 14 on January 31, 1971, with Astronauts Alan B. Shepard, Jr., Stuart A. Roosa and Edgar D. Mitchell aboard.

B. Astronauts Shepard and Mitchell established experimental base Fra Mauro, conducted two EVA's, and stayed on the Moon 33½ hours in this third manned lunar landing.

C. This was a very successful mission with the exception of docking difficulties (five attempts at docking were made before latches finally sprang into place on the sixth attempt).

D. The crew was picked up from the Pacific recovery area on February 9, 1971.

XIV. Astronauts David R. Scott, Alfred M. Worden and James B. Irwin were crew members when Apollo 15 was launched on July 26, 1971.

A. The primary purpose of this mission was to gather more information, not only about the Moon but also about the Earth, the Sun, and the solar system.

B. The astronauts landed in the Hadley-Apennine region and while on the surface of the Moon, conducted three EVA's which totaled 18 hours, 37 minutes.

C. This mission marked the first use of the Lunar Rover.

D. On August 7, 1971, the Apollo 15 astronauts returned to Earth bearing about 77 kilograms (170 pounds) of Moon rocks and thousands of photographs.

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XV. Apollo 16 was a flight of 265 hours and 51 minutes, which began at Kennedy Space Center, Florida at 12:54 p.m., E.S.T., Sunday, April 16, 1972, and ended with splashdown at 2:45 p.m., E.S.T., Thursday, April 27, in the Pacific Ocean, 346 kilometers (215 miles) southeast of Christmas Island.

A. Apollo 16's purpose was to increase man's knowledge about the Moon, planets and solar system.

B. The astronauts established experimental base Descartes, conducted three EVA's totaling a record 21 hours, and brought back to Earth 94.5 kilograms (213+ pounds) of Moon rocks.

C. The crew for this highly successful mission consisted of Astronauts John W. Young, Thomas K. Mattingly II, and Charles M. Duke, Jr.

XVI. The launch of Apollo 17 at 12:33 a.m., E.S.T., Thursday, December 7, 1972, was the third of a trio of final flights in the Apollo series. The three, Apollo 15, 16, and 17, differed from the earlier Apollo flights. They used a more advanced configuration of Apollo spacecraft which utilized more fully the space vehicle's transportation system for exploration capabilities. They also employed the lunar roving vehicle to extend the area of exploration. (See figure 13.)

A. Astronauts for the Apollo 17 mission were Commander Eugene A. Cernan, Command Module Pilot Ronald Evans and Lunar Module Pilot Harrison Schmitt.

B. The astronauts conducted three EVA's and collected about 54 kilograms (120 pounds) more of rocks than they had planned. This necessitated a reduction in their liftoff weight and the Moon explorers left a large bag of unneeded equipment on the surface.

C. As they prepared for their 5:56 p.m., E.S.T., liftoff from the Moon on Thursday, December 14, Cernan and Schmitt unveiled a plaque that read, "May the spirit of peace in which we came be reflected in the lives of all mankind." The plaque, which was signed by the three Apollo 17 astronauts and President Richard M. Nixon, also contained these words: "Here man completed his first exploration of the Moon, December, 1972 A.D."

D. The Apollo 17 astronauts splashed down in the Pacific Ocean on Tuesday, December 19.

XVII. When the Apollo 17 astronauts established experimental base Taurus-Littrow, the station complemented four other such installations set up on the Moon. The Apollo 12 astronauts set one upon the Ocean of Storms in November, 1969, Apollo 14 in the Fra Mauro region in February, 1971, Apollo 15 at the Hadley Apennine site in August, 1971, and

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UNIT VI - THE SPACE PROGRAM TODAY - INFORMATION AND AVAILABLE RESOURCES

INTRODUCTION

NASA today is a future-oriented organization of about thirty thousand employees acting in concert with industry, universities, and other Government agencies on a variety of projects in aerospace science and technology, including aeronautical research.

Today, the space program benefits man in many ways. Goal after goal has been successfully realized since NASA began with enactment of Public Law 85-568, the National Aeronautics and Space Administration Act of 1958. New knowledge, improved weather forecasting, better global communications, and new products, processes, and techniques applicable to industry, medicine, and education are among the countless benefits accruing to man from the space program.

Now that Projects Mercury, Gemini, and Apollo have been concluded, the knowledge man has gained from these missions will be utilized in future space exploration programs. Apollo 17, the last of the Apollo manned missions which was completed in December, 1972, climaxed a series of manned space flights that began with the Mercury suborbital flight of May 5, 1961.

While the Apollo manned missions were expanding man's knowledge of the Moon, NASA was proceeding with the Skylab program to establish the nation's first manned Earth-orbiting space station.

Today, the focus of the space program is on the Skylab project. Skylab is seen as the forerunner of larger and more advanced space stations and manned interplanetary spacecraft. The space station following Skylab may be a 6 to 12 man modular structure that could remain in orbit for as long as ten years. Its parts, or modules, would be flown into orbit individually and assembled there.

Another notable characteristic of the space program today is the conducting by NASA of a broad program of international cooperation in space and aeronautics. Scientists of more than seventy countries and jurisdictions have participated with NASA in joint satellite and sounding rocket projects, ground-based support such as tracking and data acquisition from spacecraft, and programs of technical training and visitor exchange.

On the home front, hundreds of companies, large and small, use NASA data dissemination centers at six universities.

The centers are designed to help industry apply technical advances made during research on space projects.

Companies are alerted to technological developments by NASA's TECH BRIEFS that describe promising innovations. Sometimes a single innovation can become an important part of an industrial process or an industry in itself.

In 1969, NASA organized Technology Application Teams. Upon request, the teams assist in identifying and applying technology derived from aerospace research and development to solve problems of national concern, such as air and water

pollution, highway safety, law enforcement, urban construction, mass transportation, and mine safety.

NASA has, from its inception, realized the tremendous importance of public relations. Periodic briefings are conducted for the press by NASA. These briefings are sometimes voluntary while at other times they are requested by the press.

Daily newspapers are put on mailing lists to receive public information regarding the space program. Major news media networks have established permanent buildings or trailers at Kennedy Space Center, Florida to cover launches.

NASA educational programs reach hundreds of thousands of students each year. Carefully trained former public school teachers and supervisors conduct lecture-demonstrations at school assemblies and classroom discussions.

More than twenty-five thousand teachers participate yearly in courses, workshops, institutes, and conferences conducted by universities and colleges, professional associations, and local and county school districts in conjunction with NASA.

To bridge the gap between information available in standard texts and the rapidly expanding knowledge to which NASA is contributing, NASA has produced a variety of publications and films. Among these are curriculum supplements that relate space to such subjects as biology, chemistry, industrial arts, physics, and mathematics; and booklets, fact sheets, films, and tape recordings to provide general information about specific aspects of the space program.

RATIONALE

NASA began with enactment of Public Law 85-568, the National Aeronautics and Space Act of 1958, approved July 29, 1958, authorizing establishment of the National Aeronautics and Space Administration. What is the status of NASA today? The learner will consider the number of operations involved in coordinating the many complex activities associated with such large facilities. The different localities, diverse number of occupations, and endless modifications reveal to the student that NASA is constantly encountering new challenges. What are these challenges and how they are incorporated within the total NASA picture can undoubtedly invigorate the interested adult into a deeper quest for knowledge about the space program.

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PRE-ASSESSMENT

1. In the following list, circle the letter of each of the seven NASA services to educational programs.

   A. Consultants
   B. Private Tours
   C. Analysis of Lunar Samples
   D. Speakers
   E. Technology Application Teams
   F. Spacemobile
   G. NASA's Tech Briefs
   H. Publications
   I. Data Dissemination Centers
   J. Audio Visual Materials
   K. Exhibits
   L. Field Trips

2. Put an X in front of the <u>two</u> examples which show the emphasis placed on public relations by NASA Headquarters.

   ___ 1. Established training program for news commentators.
   ___ 2. Conducts periodic briefings for the press, both voluntarily and by request.
   ___ 3. Conducts polls to assess public opinion of the space program.
   ___ 4. Placed daily newspapers on mailing list to receive public information regarding the space program.

3. Put an X in front of the <u>three</u> examples which show the emphasis placed on public relations by the Public Affairs Office at Kennedy Space Center.

   ___ 1. Conducts pre-launch press briefings.
   ___ 2. Made special provisions for Russian newsmen to cover manned flights.
   ___ 3. Issues permanent admittance badges to newsmen.
   ___ 4. Cooperated with major news media networks in establishing permanent facilities to cover launches.
   ___ 5. Eliminated all restrictions on visits by newsmen.

GENERAL OBJECTIVES

1. To develop an awareness of the nature and scope of the present day space program.

2. To develop an awareness of sources of available information and resources on the space program.

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SPECIFIC OBJECTIVES

1. The student will select from a list containing distractors, the seven major components of Complex 39, the nation's first operational spaceport.

2. Given a list of the network of NASA facilities, in Column A, the student will select the correct location of each from a list in Column B.

3. Given a list of industrial companies, in Column A, the student will select the correct service provided at Kennedy Space Center of each from a list in Column B.

4. The student will select from a list containing distractors, seven NASA services to educational programs which include those sponsored by state departments of education, colleges and universities, and civic groups.

5. Given a list, the student will select the two examples which show the emphasis placed on public relations by NASA Headquarters.

6. Given a list, the student will select the three examples which show the emphasis placed on public relations by the Public Affairs Office at Kennedy Space Center.

CONTENT

I. NASA began with enactment of Public Law 85-568, the National Aeronautics and Space Act of 1958, approved July 29, 1958, and authorizing establishment of the National Aeronautics and Space Administration.
   A. Agency took tangible form on October 1, 1958, with assignment to it of the 43-year-old National Advisory Committee for Aeronautics (NACA).
   B. Charged with carrying out the stated policy of the United States that "activities in space should be devoted to peaceful purposes for the benefit of all mankind."
   C. Today, a future-oriented organization of about thirty thousand employees acting in concert with industry, universities, and other Government agencies on a variety of projects in aerospace science and technology, including aeronautical research.

II. A network of NASA facilities makes up the total space program today.
   A. NASA Headquarters, Washington, D. C.
      1. Formulates policy.
      2. Coordinates activities of space flight centers.

research centers, and other installations which comprise the national aeronautics and space administration.

c. Ames Research Center, Moffett Field, California
1. Concerned with laboratory and flight research in space sciences and in aeronautics.
2. Space sciences fields include atmosphere entry research, fundamental physics, aeronautics, guidance and control, chemistry and life sciences.
3. Space flight projects - management of scientific probes and satellites, and payloads for flight experiments.
4. Management of Pioneer Project.

d. Flight Research Center, Edwards, California
1. Concerned with manned flight within and outside the atmosphere.
2. In biomathematics, man-machine integration problems are studied.

e. Goddard Space Flight Center, Greenbelt, Maryland
1. Named for the rocket pioneer, Dr. Robert H. Goddard.
2. Responsible for development and management of a broad variety of unmanned Earth-orbiting satellites and sounding rockets projects.
3. Major projects include orbiting observatories, Explorer, Nimbus, and TIROS Meteorological Technology satellites.
4. Nerve center for worldwide tracking and communications network for both manned and unmanned satellites.

f. Jet Propulsion Laboratory, Pasadena, California.
1. Research, development and flight control operated for NASA by California Institute of Technology.
2. Primary role - the investigation of planets using unmanned scientific spacecraft.
3. Supports research and advanced development related to flight projects and the design and operation of the Deep Space Network, which tracks, communicates with, and commands spacecraft on lunar, interplanetary, and planetary missions.

g. Langley Research Center, Hampton, Virginia
1. Oldest of NASA Centers.
2. Provides technology for manned and unmanned exploration of space - aid for improvement and extension of performance, utility and safety of aircraft.
3. Conceives, develops and operates simulators for aircraft and for lunar landing projects, and conducts V/STOL flight research.
4. Charged with overall project management for Viking.

h. Lewis Research Center, Cleveland, Ohio
1. Primary missions - aircraft and rocket propulsion

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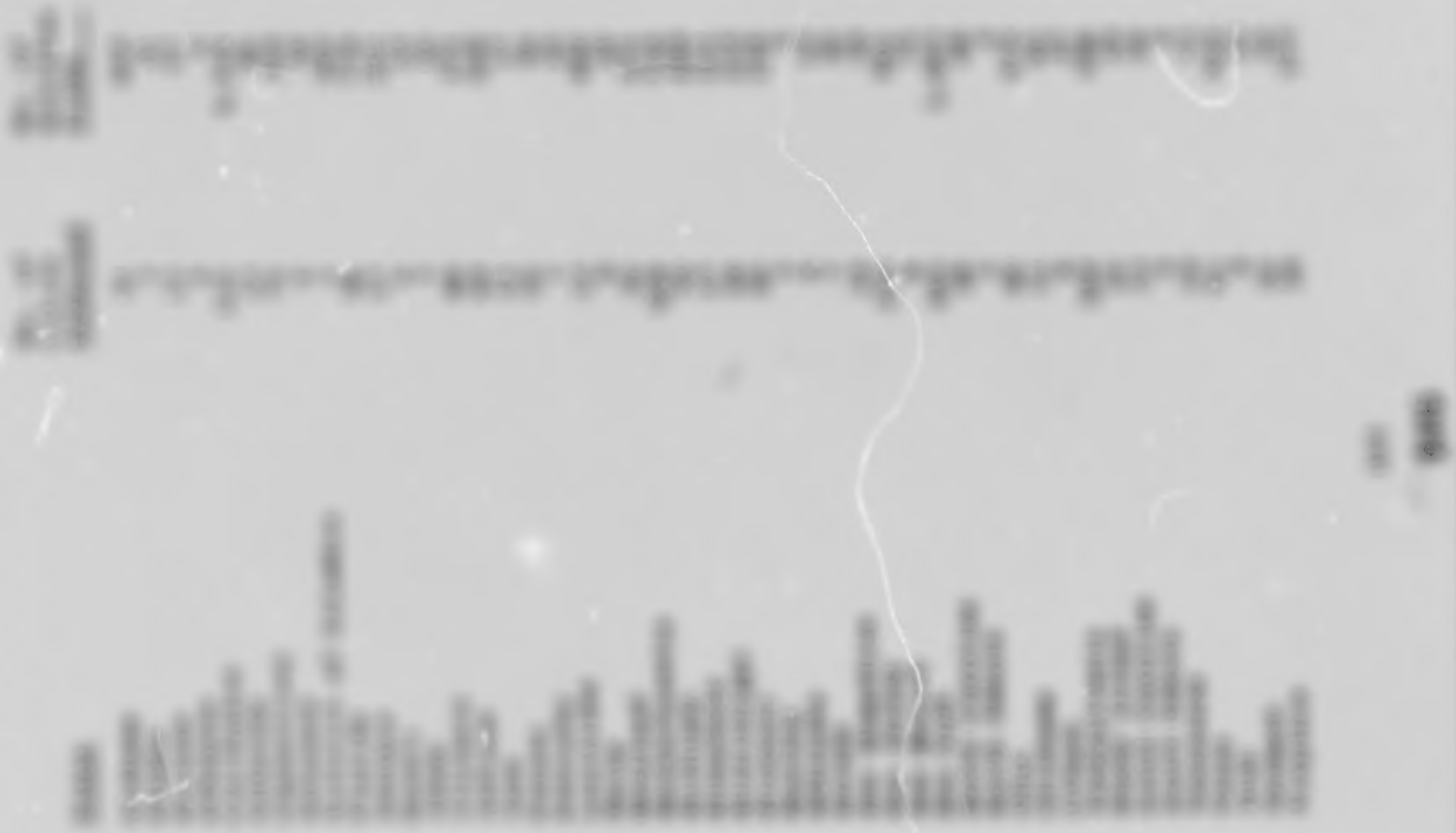

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XVI. The Industrial Area of the Kennedy Space Center is located 5 miles south of Complex 39.

A. Dr. Kurt H. Debus, Director of the Kennedy Space Center, and staff are located here. (See fugure 15.)

B. Administrators, scientists, engineers and technicians plan and accomplish operations associated with prelaunch testing and preparing space vehicles for a mission.

C. Kennedy Space Center's basic organization was changed in June 1966 when NASA approved a restructuring which allowed greater utilization of the Center's management resources.

D. The Directorate of Launch Operations executes all launch assignments.

1. Controls and integrates the work of stage contractors at the launch site to the degree necessary to achieve NASA's objectives without relieving the contractors of their mission responsibilities.
2. Assures, before launch, that engines, guidance, propellant flow systems, spacecraft, and experiments, will function as designed in space.
3. Consists of three principal departments:
   a. Launch Vehicle Operations
   b. Spacecraft Operations
   c. Unmanned Launch Operations

E. Contained also in the KSC organizational structure are three other first line directorates whose chief function is to support launch operations requirements.

1. Technical Support - Directorate manages and directs the maintenance and operation of all specialized test and launching facilities and related equipment, except launch vehicle stages and spacecraft and associated ground support equipment controlled by the Launch Operations Director.
   a. Information Systems - a major department within the Technical Support Directorate. Responsible for the supervision of telemetry, data acquisition, handling and distribution, commercial and scientific automatic data processing and calibration, and maintenance of a reference standards laboratory.
   b. Support Operations - a major department within the Technical Support Directorate. Responsible for the equipment, propellant logistics services, technical support shops and laboratories, and technical communications.
2. Design Engineering - Directorate provides continuing engineering support for launch facilities and ground systems and devices solutions to mechanical, civil and electrical - electronic requirements for existing or new launch facilities.

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3. Installation Support - Directorate collects in one management element all base housekeeping functions such as supply, security, fire fighting, industrial health services, reproduction and photography.

F. Administration - Directorate includes procurement, contract negotiations, personnel administration, and a Centerwide resources management system.

G. Latest directorate (1970) established at KSC is that of Center Planning and Future Programs.
   1. Directorate works closely with the Office of Manned Spacecraft Center and the Marshall Space Flight Center in formulating the manned space projects.
   2. Chief interest centers on the logistics shuttle, the space transportation system which is expected to become the mainstay of the NASA Program in the future.

XVII. People (the human element) are the most important aspect of the space program.

A. A vertible cross section of professions and trades are represented among employees at the John F. Kennedy Space Center.
   1. Welders
   2. Radio Technicians
   3. Doctors of Medicine
   4. Engineers
   5. Scientists
   6. Mechanics
   7. Tinsmiths
   8. Writers
   9. Photographers
   10. Truck Drivers
   11. Policemen
   12. Etc.

B. John F. Kennedy Space Center employment levels over an eight year period.

	FY64	FY65	FY66	FY67
Civil Service	1,977	2,469	2,654	2,785
Apollo Contractors	911	1,748	5,850	8,032
Unmanned Contractors	188	1,448	1,331	1,549
Support Contractors	3,204	4,116	7,739	9,116
TOTALS	6,280	9,781	17,574	21,482

(Con'd.)	FY68	FY69	FY70	FY71
Civil Service	2,911	3,000	2,967	2,600
Apollo Contractors	6,990	9,160	4,768	3,926
Unmanned Contractors	1,553	940	962	952
Support Contractors	9,829	9,000	7,011	5,681
TOTALS	21,283	22,100	15,378	12,859

C. The John F. Kennedy Space Center employment levels may be compared to more than 300,000 men and women who have been involved in the National space program over the years.

XVIII. Some of the giant companies of American industry as well as smaller and more specialized organizations are engaged at Kennedy Space Center.

A. Boeing Aircraft Company
   1. The largest employer at Kennedy Space Center.
      a. Provides plant engineering, maintenance, logistics support, security and publications.
      b. TWA operates a Visitors Information Center and Greyhound Bus Lines, a subcontractor, conducts public tours of the Space Center.

B. Bendix Corporation provides launch support services for Complex 39.

C. Federal Electric Corporation provides instrumentation, data acquisition and processing and communications support for the Space Center.

D. McGregor & Werner, Inc. provides reproduction services.

E. General Electric - services and equipment for checkout and integration of manned spacecraft.

F. Pan American World Airways - engineering support and modification services for launch, test, laboratory and supporting facilities.

G. Boeing Company - Saturn V first stage builder, site activation, luanch support.

H. Chrysler Corporation - Manufacturers of Saturn IB first stage launch support.

I. McDonnell Douglas Corporation - fabricates the Saturn IB second stage, the Saturn V third stage and the Delta launch vehicle.

J. North American Rockwell - builds Saturn V second stage and Apollo spacecraft.

K. International Business Machines Corporation - provides

the Saturn IB and Saturn V instrument units.
L. Grumman Aircraft Engineering Company, Inc. - contractor for the Apollo lunar module.
M. General Dynamics/Convair - contractor for the Atlas-Centaur vehicle.
N. New World Services - library.
O. Pan American World Airways - medical services.
P. Technicolor Corporation provides photographic services.

XIX. The nature of the activities conducted at the nation's only spaceport commands the existance of an extremely thorough Public Affairs Office.
A. Pre-launch press briefings are held at Kennedy Space Center.
1. Keep Community leaders appraised of launch progress.
2. Local leaders include Brevard County's bank presidents, Chamber of Commerce presidents, school superintendent, etc.
3. Still photographs are produced and made available to public.
B. Permanent admittance badges issued to newsmen.
1. Newsmen come and go at will with exceptions.
2. Monday through Friday visits.
3. Normal working hours only for visits.
C. Major news media networks established permanent buildings or trailers at Kennedy Space Center to cover launches.
1. Admittance badges are issued to a large number of foreign newsmen for each launch.
2. Russia has never sent a newsman to cover a launch through Apollo 17.

XX. Early in the development of the John F. Kennedy Space Center, NASA entered into an agreement with the Department of Interior's Bureau of Sport Fisheries and Wildlife to establish a wildlife refuge within the confines of the Center. (See figure 16.)
A. Paragraph 10 of the agreement states:
"The Bureau shall use said property as a National Wildlife Refuge to promote the conservation of wildlife, fish and game, for recreational and educational purposes, and for other purposes embodying the principles and objectives of planned multiple land use"
B. The refuge boundaries are superimposed on those of the Spaceport except for the areas required to support Apollo and programs such as Skylab in 1973 and the Space Shuttle in the future.

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transmission, new types of transducers, or energy transformers, have been developed so that, for example, a temperature is not measured by a thermometer which has to be looked at, but by a thermoelectric device which produces voltage changes which, in turn, are transmitted for recording or display at a remote location.

This unit concerns itself with some of the basic scientific concepts relating to the space program which can be readily enforced through the use of teacher lectures along with audio-visual aids, thus, eliminating the necessity of scientific experiments in a laboratory.

RATIONALE

History tells us that flight has always challenged man's imagination. Most of man's early attempts with flying devices ended in failure. Some men were finally successful in flying with their machines.

Rockets were born hundreds of years ago, but only recently were actually used to lift man into space after science developed better propulsion and guidance systems.

The rapid advance of the sciences, in a short span of years, has changed the course of human events for all time.

This unit of the curriculum guide is designed to give the student an awareness of some of the basic scientific concepts relating to the space program. The basic concepts will orient the student to scientifically analyze the total spectrum of space.

PRE-ASSESSMENT

Complete each of these sentences by drawing a circle around the correct word or phrase that belongs in the blank space.

1. _____ discovered two zones of radiation in existence around the Earth.

   a. Dr. Robert H. Goddard b. Sir Isaac Newton
   c. Sir William Congreve d. Dr. James VanAllen

2. Dark spots on the Sun are known as _____.

   a. flares b. sunspots c. magnetic fields
   d. solar wind

3. The Earth has the shape of an _____ which means it is like a sphere, but flattened at the poles.

   a. Oblate spheroid b. oval c. apogee d. ellipse

4. The constant turning motion of the Earth is called _____.

   a. revolution b. rotation c. orbital motion
   d. gravitation

5. The Earth's moving around the sun is its _____.

   a. revolution b. rotation c. orbital motion
   d. gravitation

6. _____ carried frog eggs, microorganisms, plants, and insects into space in an experiment designed to study the effects on living things of such phenomena as weightlessness, weightlessness combined with radiation, and removal from the day-night cycle on Earth.

   a. Explorer I b. Biosatellite c. ATS-F
   d. Mariner IV

7. The _____ is the most electronically complex unmanned spacecraft ever developed by the U. S.

   a. Orbiting Solar Observatory (OSO) b. ATS-G
   c. Orbiting Astronomical Observatory (OAO) d. Mariner

8. Finding and following spacecraft as they crisscross the sky overhead is called _____.

   a. telemetry b. attitude control c. relay
   d. tracking

9. Flights of _____ are short in terms of time and distance.

   a. sounding rockets b. satellites c. space probes
   d. jet aircraft

10. _____ will broadcast educational TV programs to villages and rural areas in a joint experiment with India.

    a. Intelsat b. ATS-F/G c. Nimbus d. Mariner II

11. The radio transmission of messages from artificial satellites to Earth tracking stations is called _____.

12. The _____, first launched in 1962, measured energetic particles emitted from the sun and provided information on sunspots.

    a. Orbiting Astronomical Observatory (OAO) b. Nimbus 1
    c. Intelsat I d. Orbiting Solar Observatory (OSO)

13. The goal of Mariner V was to provide scientists with information about the planet _____.

    a. Jupiter b. Venus c. Saturn d. Mars

14. Mariner IV was launched with the goal of providing scientists with information about the planet _____.

    a. Mars b. Venus c. Jupiter d. Saturn

15. _____satellites orbit over the Equator at altitudes of about 35,900 kilometers (22,300 miles) and to the observer on the Earth below, appear to remain in the same spot in the sky.

    a. Synchronous b. Geostationary c. Communication
    d. Meteorological

GENERAL OBJECTIVE

To help adults become familiar with basic Earth, physical, and biological science information as it relates to the space program.

SPECIFIC OBJECTIVES

1. The student is to be able to complete a 15-item multiple-choice examination on the subject matter contained in Unit VII. The lower limit of acceptable performance will be nine items answered correctly within an examination period of 45 minutes.

2. Given seven characteristics descriptive of the Orbiting Astronomical Observatory (OAO), and the Orbiting Solar Observatory (OSO), the student will classify them correctly.

3. Given a list of satellites in Column B the student will select the one correct launch objective of each from a list of objectives in Column A.

CONTENT

I. Dr. James VanAllen discovered two zones of radiation in existence around the Earth.
   A. The doughnut shaped zones are called the VanAllen radiation belts or zones.
   B. The central part of the first zone is approximately 3,200 kilometers (2,000 miles) from Earth while the central part of the second zone is 16,000 kilometers (10,000 miles).
   C. Explorer and Pioneer satellites provided scientists with information about radiation in the zones.

II. Physicists using instruments in Antarctica to learn more about Earth's magnetic field found that it is probably affected by other magnetic fields out in space.
   A. The dark spots on the Sun are known as sunspots and are considered to be the Sun's "storms".
   B. The sunspots, large enough to be seen by the eye when examined through darkened glass, originate beneath the surface and cause great columns of gas to rise to the surface. The gases expand rapidly, flow outward from the center of the spot, and cause a violent, whirling motion in the surface gases around the spot.
   C. Brilliant eruptions known as flares occur near sunspots, and strong magnetic fields develop in the area of the spots.
   D. Disturbances on the Sun are tremendous in size, dwarfing the Earth by comparison. The largest sunspots cover an area on the Sun more than 30 times the surface of the Earth.

III. The Orbiting Astronomical Observatory (OAO) was designed to collect important information about the Sun and the stars.
   A. The OAO, NASA's largest scientific satellite, is the most electronically complex unmanned spacecraft ever developed by the United States. (See figure 18.)
   B. The OAO measured the magnetic field of the Earth.

IV. The Orbiting Solar Observatory (OSO) was first launched in 1962.

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A. An important innovation on OSO-1 was the 'sail' portion of the spacecraft that always pointed at the Sun.
B. Accurate instrument pointing is crucial to space astronomy. The OSO-1 was the first satellite to look onto a star, the Sun, with instruments that see outside the visible portion of the spectrum.
C. The OSO contributed in ever-increasing ability to find specific stars and point instruments on them, steadily, for long periods of time.
D. The OSO measured energetic particles emitted from the Sun and provided information on sunspots.

V. The Earth has the shape of an oblate spheroid, which means it is like a sphere, but flattened at the poles.
A. The constant turning motion of the Earth is called <u>rotation</u>.
B. Earth's moving around the Sun is its <u>revolution</u>. (NOTE: Review Kepler's law of planetary motion, Unit I.)

VI. A great deal of information about Venus and Mars has been acquired through close range observations made possible by NASA's Mariner spacecraft.
A. Mariner II came within 34,632 kilometers (21,645 miles) of Venus and provided man with the most significant advances in knowledge about the planet Venus.
B. Mariner V, launched to Venus on June 14, 1967, to refine results from Mariner II and acquire new information, swept within about 40,000 kilometers (2,500 miles) of the planet in October 1967.
C. Mariner V provided data that enabled scientists to draw several conclusions.
1. An apparent Venusian surface temperature that may be as hot as 800 degrees F was revealed.
2. The atmosphere has critical refractivity (atmosphere is so deep and dense it could capture light and radio waves so that they circle the planet rather than go to the surface or shoot out into space).
3. The major constituent of the Venus atmosphere appears to be carbon dioxide.
4. Complete answers on the surface of Venus, the atmosphere, and the possibility of life, were not provided.
5. Mariner flights carrying more elaborate instruments were required before additional conclusions could be drawn.
D. Mariner IV swept by Mars on July 14, 1965 (Mariners I and III failed). NOTE: Review "Mariner", Unit III, No. XVIII.
1. A Martian surface pockmarked by craters was revealed.
2. The atmosphere of Mars was shown as only about one per cent as dense as Earth's (much less than needed for most types of Earthly life).

3. There was no detection of a Martian magnetic field, nor a radiation region such as exists around the Earth.
4. The data increased knowledge about the properties of the outer planets, in terms of atomic particles of hydrogen, helium, and other elements.

VII. [illegible]'s Discoverer II (Sat Unit III, Sa. 902-4 experiment was designed to study the effects on living things of such phenomena as weightlessness, weightlessness combined with radiation, and removal from the diurnal (day-night) cycle on Earth.

A. Discoverer I, launched November 14, 1960, could not be brought down as scheduled because of retrorocket failure. Efforts to locate the craft during the subsequent manned recovery on February 14, 1961, were unsuccessful.

B. AFBM launched Discoverer II from Cape Canaveral on September 7, 1961.

1. Two days after launch, ground controllers ordered the satellite to fire retrorockets, slowing it so that it fell out of orbit toward Earth. As it parachuted down over the Pacific near Hawaii, the spacecraft was retrieved in the air by a United States Air Force plane.

2. Discoverer II carried frog eggs, microorganisms, plants, and insects.

C. Living cargo was subjected during flight to weightlessness alone and to weightlessness combined with radiation which was artificially applied from a source on the spacecraft.

1. It appeared that Earth's growing commercial plant growth to a greater degree than previously realized.

2. Bacteria seemed to multiply more readily in space than on Earth (for every 12,000 that were sent up, a billion returned - experimenters theorized without the restraints of gravity, the bacteria found it easier to take in nutrients and give off waste, thus allowing a greater part of their metabolism to be devoted to reproduction).

3. As on Earth, young and rapidly dividing cells in a weightless environment appeared to be more severely affected by radiation than mature slowly growing cells.

4. Plant life reacted far more to weightlessness than animal life.

5. Scientists cautioned that Discoverer II experiments were with relatively simple organisms and the findings could not be transferred directly to man.

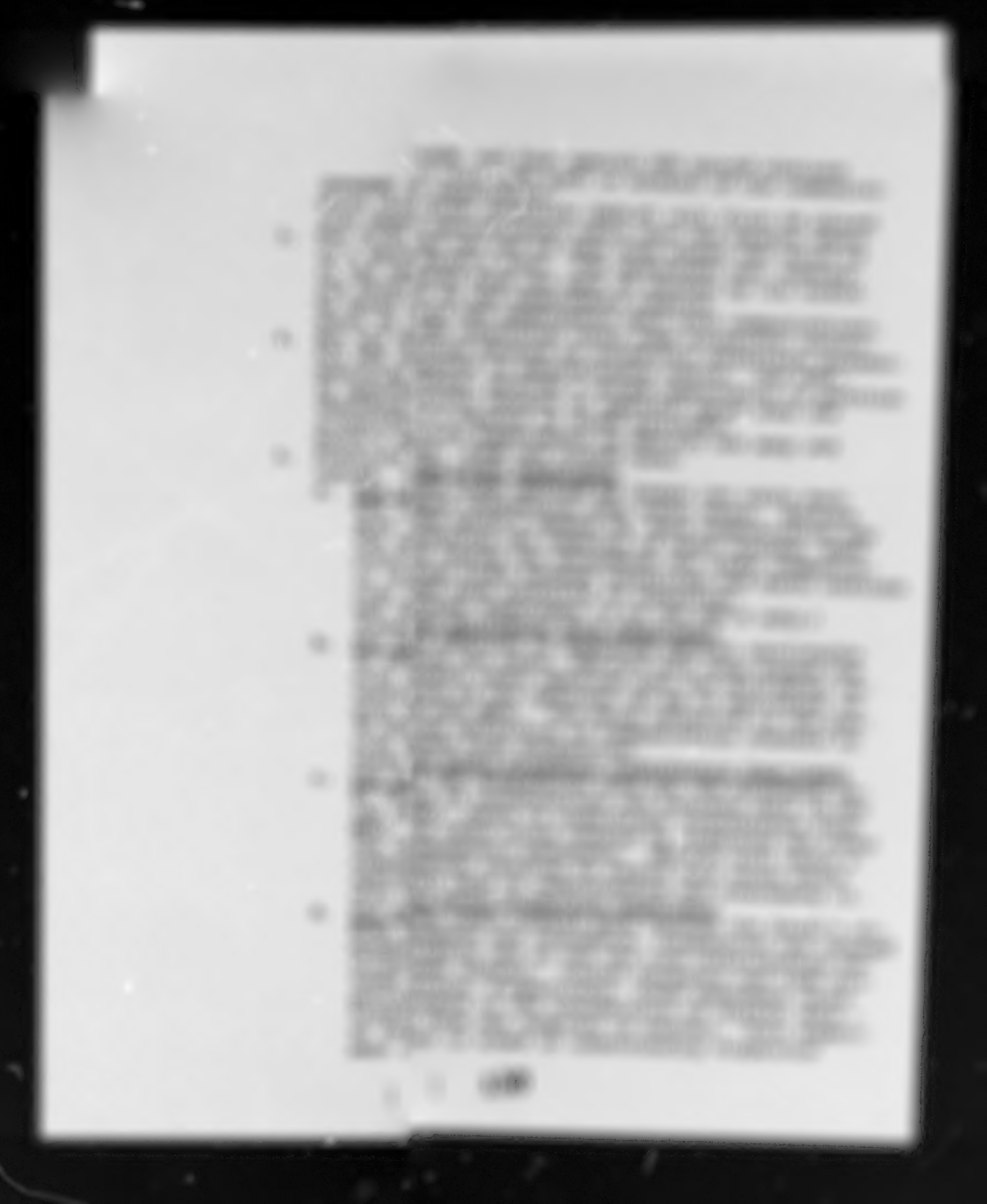
6. Discoverer II experiments and other experiments which followed, added new dimensions to man's knowledge about life.

[illegible]

[illegible]

[illegible]

[illegible]



the atmospheric sciences, and the orbital survey of Earth resources.

6. To conduct experiments designed to study the effects on living things of such phenomena as weightlessness, weightlessness combined with radiation, and removal from the diurnal (day-night) cycle on Earth.

7. To acquire information about the planet Venus.

8. To improve the positional accuracy of geodetic control stations and spacecraft tracking stations.

II. To the right of each of the statements below, check whether it is a characteristic of the Orbiting Astronomical Observatory (OAO) or the Orbiting Solar Observatory (OSO).

	OAO	OSO
1. This is the largest of NASA's scientific satellites.	___	___
2. An important innovation on this satellite was the "sail" portion of the spacecraft that always pointed at the Sun.	___	___
3. Accurate instrument pointing has been crucial to space astronomy, and this satellite was the first to lock onto a star--the Sun--with instruments that saw outside the visible portion of the spectrum.	___	___
4. This is the most electronically complex unmanned spacecraft ever developed by the United States.	___	___
5. This satellite measured the magnetic field of the Earth.		
6. This satellite contributed to the ever-increasing ability of scientists to find specific stars and point instruments at them--steadily, for long periods of time.	___	___
7. This spacecraft measured energetic particles emitted from the Sun and provided information on sunspots.	___	___

III. It is recommended that the pre-assessment activity be administered again.

PRE-ASSESSMENT ANSWER KEY

1. Dr. James Van Allen
2. sunspots
3. oblate spheroid
4. rotation
5. revolution
6. Biosatellite II
7. OAO
8. tracking
9. sounding rockets
10. ATS-F/G
11. telemetry
12. OSO
13. Venus
14. Mars
15. Geostationary

POST-ASSESSMENT ANSWER KEY

I. 4 A.
7 B.
6 C.
3 D.
1 E.

II. 1. OAO
2. OSO
3. OSO
4. OAO
5. OAO
6. OSO
7. OSO

III. See Pre-Assessment Answer Key

UNIT VIII - SPACE PROGRAMS

INTRODUCTION

Manned space flight programs have been primarily concerned until now with learning how to operate effectively and safely in space environment while accomplishing missions of increasing complexity and value. The astronauts have been test pilots undertaking experimental flights. Overall, our objective has been to build a manned space flight capability. Now, an increasingly complex set of missions using increasingly complex spacecraft has been completed successfully in the Mercury, Gemini and Apollo Programs. Their success attests to the maturing of that capability. With this capability in hand, we can pay considerably more attention to the scientific objectives that can be achieved by employing men at the scene of the activity. We have established follow-on programs to the lunar landing in which scientifically trained astronauts will employ Apollo space vehicles in programs oriented toward scientific experimentation. (See figure 19.)

Such a program is the Skylab Program. Three astronauts occupy this Earth orbiting laboratory for continuous periods as long as two months. They use the equipment installed to conduct scientific experiments, make solar observations and to determine the effects of long space missions on the health of the crewmen.

Another program, the Space Shuttle, has as its goals, to bring into operation a fully reusable vehicle capable of

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carrying up to 29,500 kilograms (65,000 pounds) of payload (passengers, cargo or a combination of the two) on both legs of the round trip between Earth and Earth orbit. This low cost transportation system can be developed without increasing NASA funding over the current 1972-73 budget.

Other future space programs are outlined in Unit VIII.

RATIONALE

What are the different space programs presently incorporated within the NASA perspective at the present time? Awareness of the orientation developed and how it is affecting man will assuredly stimulate the mind. The cooperative agreement between the U. S. and Russia in space exploration and the ecological research developed are only two of the many interesting projects challenging NASA today. An investigation into the future characterizes the creativity necessary for the continuation of these unique programs.

CONTENT

I. Project Apollo's lunar missions ended when Apollo 17, with astronauts Eugene A. Cernan, Harrison H. Schmitt and Ronald E. Evans aboard the spacecraft America, splashed down in the South Pacific at 2:24 p.m., Tuesday, December 19, 1972.

II. Skylab is America's first experimental space station, the next advance in manned space flight following Project Apollo's lunar missions. (See figure 20.)
   A. Three-man crews conduct over 50 experiments during space missions as long as 59 days in the Skylab workshop, America's first manned space station.
   B. Skylab evaluates systems and techniques designed to gather information on Earth's resources and environmental problems such as pollution of air and water, flooding, erosion, weather, crop deterioration, and mineral deposits.

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1. Solar telescopes are substantially increasing man's knowledge of the Sun and the multitude of solar influences on Earth's environment.
2. Medical experiments on Skylab are planned to increase knowledge of man himself and his relationship to his Earthly environment and adaptability to space flight.
3. Skylab also experiments with industrial processes which may be enhanced by the unique weightless and vacuum environment of orbital space flight.

III. The Skylab mission began when at 1:30 p.m. EST on May 14, 1973, a two-stage Saturn V vehicle lifted off from Pad A of Launch Complex 39, at the Kennedy Space Center in Florida. Atop the giant rocket sped an unmanned orbital Workshop the size of a three bedroom house.
A. The Skylab payload consisted of the Workshop, Apollo Telescope Mount, Airlock Module, and Multiple Docking Adapter. (See Figure 2).
B. About one minute after lift off aerodynamic forces ripped off the combination man-screen and micrometeroid shield.
1. Instrumentation reported that the cabin was beginning to overheat badly. Temperatures reached 125 degrees Fahrenheit or higher.
2. The Sun's rays were beating down directly on the unprotected roof.
3. The same accident had torn off one of two solar power wings intended to transform the Sun's rays into electrical energy and the other stuck before it could deploy.
4. Skylab suffered a serious loss of electrical power and an overheated condition due to the loss of the shielding's thermal protection. Ground controllers surveyed the orbiting space station from one million to another to several temperatures and still obtain enough sunlight for power generation.

IV. Skylab 2 (SL-2), the Apollo Command-Service Module that was to take Astronauts Charles Conrad, Jr., Joseph P. Kerwin, and Paul J. Weitz into orbit to rendezvous with the unmanned Workshop, had been scheduled for launch on May 15, 1973, one day after SL-1.
A. The launch had to be postponed.
B. Efforts began to devise a sunshield that the astronauts could deploy in space. Several different approaches were worked out, and the astronauts practiced for many hours on the mockovers they would have to perform to work on the shield outside the space station once they had completed rendezvous.
C. The ability changing of the spacecraft's attitude by

[illegible]

a. [illegible]

b. [illegible]

c. [illegible]

d. [illegible]

e. [illegible]

f. [illegible]

g. [illegible]

h. [illegible]

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j. [illegible]

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m. [illegible]

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q. [illegible]

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s. [illegible]

t. [illegible]

u. [illegible]

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w. [illegible]

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uuuu. [illegible]

vvvv. [illegible]

wwww. [illegible]

xxxx. [illegible]

yyyy. [illegible]

zzzz. [illegible]

[illegible]

[illegible]

(a) [illegible]

(b) [illegible]

(c) [illegible]

(d) [illegible]

(e) [illegible]

(f) [illegible]

(g) [illegible]

(h) [illegible]

(i) [illegible]

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F. The initial launch and landing site for the shuttle will be at the Kennedy Space Center, Florida. This site will be used for research and development launches, expected to begin in 1978, and for all operational flights launched into east-west orbits.

G. Toward the end of the decade it is planned that a second operational site will be added at Vandenberg Air Force Base, California, for north-south orbits. The basic shuttle facilities required at Vandenberg are planned to be provided by the Department of Defense.

H. It is estimated that development of the shuttle system will cost about $5.15 billion (about one-fourth the cost of the Apollo program), and it will take six years to produce the initial test vehicle.

I. Each flight will cost about $10.5 million, far less than any other space vehicle with an equivalent payload capacity.

J. Each payload pound the shuttle carries will cost about $160.00, as compared to a current $900.00 and up per pound, with conventional launch vehicles.

K. On July 26, 1972, NASA announced the selection of the Space Division of North American Rockwell for "negotiation" of a contract to begin development of the space shuttle system. (See figure 26.)

XX. In NASA's Man on Mars Project, manned flights similar to the Apollo lunar missions may be attempted in the 1980's. (See figure 27.)

A. NASA's basic strategy is similar to that employed in lunar exploration; namely, the following sequence of ever-more-sophisticated spacecraft: fly-by, orbiter, unmanned lander, and manned lander.

1. "Fly-by" spacecraft such as NASA's Mariners pass close to Mars and scan it with instruments.
2. The "Orbiter" spacecraft surveys the planet from orbit. Nasa's Lunar Orbiters typify this class.
3. The "Unmanned Lander" spacecraft softlands on the surface and radios data back to Earth. Example: America's lunar Surveyor spacecraft. (Also unmanned missions for sample returning when atmospheric and surface samples are acquired and brought back to Earth.)
4. The "Manned Lander" is that spacecraft such as used in the Apollo flights to the Moon.

B. Viking is a follow-on to the 1964-65, 1969 and the 1971 Mariner flights to Mars.

1. The first two Mars missions, in 1965 and 1969, flybys of the planet, sent back pictures and information on the Martian atmosphere.
2. Mariner 8 fell victim to a failure of the Centaur stage of the Atlas-Centaur launch vehicle and did

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not achieve a trajectory towards Mars.

3. Mariner 9 was successfully launched on May 30, 1971, and arrived at Mars on November 13, 1971.
   a. Mariner 9 gave scientists a long look at the Martian surface and helped them select propitious targets for the Viking landers.
   b. A mapping mission of the Martian surface was undertaken and a study was made of the features of Mars that vary with time.

C. The Viking Project was to have been launched in 1973 but was rescheduled to 1975.

D. Langley Research Center, Hampton, Virginia, is charged with overall project management for Viking and responsibility for the lander portion of the spacecraft. Jet Propulsion Laboratory, Pasadena, California, will manage the orbiter portion of the project and is responsible for tracking and data acquisition.

E. Viking will consist of two instrumented spacecraft which will be placed in orbit around Mars with each spacecraft detaching a landing capsule for descent to the surface and soft landing. Mission objectives include the detection of life on the planet if it exists.

SPACE AWARENESS VOCABULARY

Skylab	Trajectory	Unmanned Lander
Shuttle	Orbiter	Manned Lander
Fly-by	Project Viking	Space Station

SUGGESTIONS FOR THE TEACHER

Historians in the centuries ahead will record the 1970s as the critical decade that bridged the evolution between spatial exploration and the successful harnessing of space for the practical benefits of man on Earth. The principal means of transportation that will make such a monumental transition possible, in such a relatively short span of time, is the Space Shuttle which is discussed in this unit.

Considering the fact this unit does not have a pre-assessment nor post-assessment activity, you should take the opportunity to review in depth what man has accomplished in the space program to date. Use this review to stimulate the students to eagerly seek information on what is to come.

There are several possible ways of beginning the study of this unit in such a way as to arouse new interest and to suggest additional study.

Discussion of an imaginary trip to some other planet is always interesting. This might well be used to raise many questions. Which planet is always interesting. This might well be used

to raise many questions. Which planet would be most interesting to visit? How far away is it? How could we go there and how could we get back? What has already been accomplished in the U. S. Space Program toward the exploration of other planets?

Lead your students in a discussion covering the transition from Apollo 17 to Skylab. What were the accomplishments of Project Apollo? How are the accomplishments of the Apollo program to be used in the Skylab Project?

Have your students suggest ways in which they personally could benefit from the Space Shuttle.

Try to acquire NASA publications NF-43, Skylab, and NF-44, Space Shuttle, in sufficient quantities to make them available to your class. These are fold outs that are very well illustrated and explains these two programs in language the layman can understand.

If you elect to introduce the unit with a film, consider, To Worlds Beyond. This is a 27 minute color film which begins with Jules Verne's predictions and shows through photography and simulation how one travels through space. This is a very informative film and it is rated excellent for adult education.

In addition to these suggestions, refer to the overall suggestions for the teacher at the beginning of the guide.

ILLUSTRATIVE RESOURCES

NASA Publications:
NF-43 Skylab
NF-44 Space Shuttle
EP-22 This is NASA
EP-57 America in Space/The First Decade - Man in Space
EP-81 Man in Space - Space in the Seventies
EP-75 Space Station - Key to the Future
American in Space/The First Decade - Exploring the Moon and Planets

Textbooks:

Wolfe, Battan, Fleming, Hawkins, and Skornik, Earth and Space Science, D. C. Heath and Company, Boston.

MacCracken, Decker, Read and Yarian, Scientists Solve Problems, L. W. Singer Company, Second Edition.

Brandwein, Beck, Strahler, Hollingworth and Brennan, The World of Matter-Energy, Harcourt, Brace and World, Inc.

Films:

Rehearsal for the Moon (color) 7:10 minutes
A Mission for Mariner (color) 12:30 minutes
To Worlds Beyond (color) 27:15 minutes
Behind the Headlines in Space (color) 29 minutes
The Guaymas Story (color) 27:15 minutes

POST-ASSESSMENT

I. To the right of each statement, check whether it is a characteristic of the Command Module, Service Module, or Lunar Module.

	Command Module	Service Module	Lunar Module
1. Contained supplies, fuel and rocket engines.	____	____	____
2. This was similar to a crew compartment of a commercial jet airliner.	____	____	____
3. This was the only section of the three-section spacecraft which returned to Earth.	____	____	____
4. This carried two of the three Apollo astronauts to the Moon's surface and landed.	____	____	____
5. This was jettisoned after the two astronauts rejoined the third one in the parent craft.	____	____	____
6. This had to be constructed to withstand tremendous deceleration forces and intense heat.	____	____	____
7. The module which contained rocket engine which enabled the astronauts to maneuver into and out of lunar orbit and alter their course and speed in space.	____	____	____

PRE-ASSIGNMENT ANSWER KEY

I. A. To land astronauts on the Moon.
   F. To explore the lunar surface.
   G. To conduct scientific experiments on the Moon to furnish scientific data on Earth.
   F. To obtain lunar samples.
   G. To return astronauts safely to the Earth.

POST-ASSIGNMENT ANSWER KEY

I. 1. Service Module
   2. Command Module
   3. Command Module
   4. Lunar Module
   5. Lunar Module
   6. Command Module
   7. Service Module

II. The Manned Spacecraft Center at Houston, Texas
    The Marshall Space Flight Center at Huntsville, Alabama
    The John F. Kennedy Space Center in Florida

[illegible]

[illegible]

accomplishment /.../ The state of attainment of objectives. /.../ The act of attaining an accomplishment, as the object of formal accomplishment.

accomplishment of the social condition of /.../ The accident contributes to [illegible] of a society's cultural goals. /.../ It does not accomplish.

achieve /.../ To succeed in reaching desired objectives by one's efforts. /.../ Implies an if success determined in the aggressive direction.

goal (group, organ) /.../ The purpose of a group [illegible] and organizational activities [illegible]. From outside the organization, [illegible] goal [illegible] objectives.

The primary goals are [illegible] charter. The secondary objectives [illegible] goals of [illegible] are to [illegible] [illegible] [illegible]

abandon *vt.* (Often) used in the sense: the first two words of a file name specification. Typically, the first word is a command and the second word is the name of a file to be acted upon by that command.

abend *vi.* Abnormal termination. The machine halts or aborts execution of the current program.

abend *interjection.* The machine halts or aborts execution of the current program.

abort *n.* From ABEND. Abrupt termination of execution (usually of a program). Used in the sense of "to abort".

abort *vt.* To terminate a process abruptly. Usually implies that the process is killed in such a way that it cannot intercept itself. Sometimes used transitively to imply that a process has been killed. Also used intransitively to imply that a process has been killed. Synonymous with ABEND and SCRUB.

absolute address *n.* Synonym for *machine address*. Sometimes used to emphasize that the address is not relative to a base address, but is the one actually used to address memory. Sometimes used to emphasize that the address is not relative to a segment. In a segmented architecture, this usually means that the address is relative to the start of the segment, sometimes to the program counter, or to some other segment. Sometimes used to imply that the address is relative to the start of memory.

absolute pointer *n.* A pointer used to provide information about a file position.

absolute value *n.* What mathematicians call the magnitude of a number: the number stripped of its sign. Computer people often use this term when they mean *modulus*, which is the distance from zero on the number line, and which is also the result of the ABS function in most programming languages.

absolute zero *n.* The coldest temperature possible, at which point all molecular motion ceases except for the vibrations which represent heat that cannot be removed from the substance. Absolute zero is 0 degrees Kelvin, -273.16 degrees Celsius, or -459.69 degrees Fahrenheit.

absorption element *n.* A number which, when multiplied by any number, yields itself. Usually applied to zero, but one is the absorption element for exponentiation.

abstract *adj.* Used loosely to describe something which embodies the essence of something else, or which serves as a simple model for a more complex reality. Contrast *concrete*.

abstract class *n.* In object-oriented programming, a class that is not instantiated directly, but is used to derive other classes. Abstract classes usually contain one or more deferred methods.

abstract data type *n.* A data type defined in terms of the operations that can be performed on it, rather than in terms of how it is represented in memory or how the operations are implemented. Typically, the definition includes a function that creates instances of the type, functions that operate on instances of the type, and functions that destroy instances of the type. Sometimes called a *data manager*.

abstract machine *n.* A hypothetical machine defined in such a way that its properties can be directly compared with those of real computers. Abstract machines are frequently used in language definitions (to avoid biasing the definition toward any particular implementation) and in theoretical discussions of computation.

abstraction *n.* The process of forgetting information in such a way that the resulting description is useful for some purpose and is not misleading with respect to what has been forgotten. In programming, the most common type of abstraction is to define a data object in such a way that the manner in which its components are stored is ignored, allowing attention to be focused on manipulating it correctly rather than worrying about how it is laid out. Abstraction is the primary purpose of procedures and functions. Abstraction is the opposite of *refinement*.

abstraction barrier *n.* A technique used in structuring programs, in which the implementation of each function is insulated from the rest of the program so that it can be changed without affecting anything but the function itself. Abstraction barriers are usually implemented by passing all data that are to be manipulated by a function in the form of abstract data types.

used as a unit of stress measurement for bodies undergoing acceleration.

galaxy. A vast assemblage of stars, nebulae, etc., composing an island universe separated from other such assemblages by great distances.

The sun and its family of planets is part of a galaxy commonly called the Milky Way. The nearest galaxy to the Milky Way is the spiral galaxy Andromeda at a distance of approximately 800,000 light years.

geo. A prefix meaning "earth," as in "geology," "geophysics."

Some writers use the established terms such as "geology" to refer to the same concept on other bodies of the solar system, as "the geology of Mars," rather than "areology" or "marsology," "geology of the Moon," rather than "selenology."

geodetic. Pertaining to geodesy, the science which deals with the size and shape of the earth.

gravitation. The acceleration produced by the mutual attraction of two masses, directed along the line joining their centers of mass, and of magnitude inversely proportional to the square of the distance between the two centers of mass.

gravity. The force imparted by the earth to a mass on, or close to the earth. Since the earth is rotating, the force observed as gravity is the resultant of the force of gravitation and the centrifugal force arising from this rotation.

gyroscope. A device that spins and, by its motion, keeps a vehicle from changing its course.

H

hazard. A source of danger.

humidity. 1. The amount of water vapor in the air. 2. Specifically, relative humidity.

hydrogen. The lightest of the elements.

hydrosphere. That part of the earth that consists of the oceans, seas, lakes, and rivers; a similar part of any other spatial body if such a body exists.

hyperbola. An open curve with two branches, all points of

which have a constant difference in distance from two fixed points called focuses.

hypogolic propellants. Rocket propellants that ignite spontaneously when mixed with each other.

I

inertia. 1. Tendency of an object at rest or when in motion to continue in motion at the same speed in a straight line. 2. Resistance to acceleration.

infrared radiations. 1. Electromagnetic radiation lying in the wavelength interval from about 75 microns to an indefinite upper boundary sometimes arbitrarily set at 1000 microns (0.01 centimeter). Also called long-wave radiation. 2. Radiations lower in frequency than red light, but longer in wavelength.

inorganic compound. In general a substance which does not contain carbon or a compound containing carbon.

internal combustion. The burning of fuel inside a cylinder or combustion chamber to provide power for doing work.

interplanetary. Existing, carried on, or operating between planets.

International Geophysical Year (I.G.Y.). An 18-month period from July 1957 through December 1958 in which scientists from many nations cooperated in special studies on the Earth and space; extended indefinitely as the I.G.C. or the International Geophysical Cooperation.

J

jet. 1. A strong well-defined stream of fluid either issuing from an orifice or moving in contracted duct, such as the jet of combustion gases issuing from a reaction engine, or the jet in the test section of a wind tunnel. 2. A jet engine, as, an airplane with jets slung in pods.

jet engine. 1. Broadly, any engine that ejects a jet stream of gas or fluid, obtaining all or most of its thrust by reaction to the ejection. 2. Specifically, an aircraft engine that derives all or most of its thrust by reaction to its ejection of combustion products (or heated air) in a jet and that obtains oxygen from the atmosphere for the combustion of its fuel (or outside air for heating, as in the case of the nuclear jet engine), distinguished

in this sense from a rocket engine. A jet engine of this kind may have a compressor, commonly turbine-driven, to take in and compress air (turbojet), or it may be compressorless, taking in and compressing air by other means (pulsejet, ramjet).

jettison. 1. To make jettison of. 2. To cast off as an encumbrance, discard. 3. To drop from an airplane in flight.

K

Kepler laws. The three empirical laws governing the motions of planets in their orbits, discovered by Johannes Kepler (1571-1630). These are: (a) the orbits of the planets are ellipses, with the Sun at a common focus; (b) as a planet moves in its orbit, the line joining the planet and Sun sweeps over equal areas in equal intervals of time (also called law of equal areas); (c) the squares of the periods of revolution of any two planets are proportional to the cubes of their mean distances from the Sun.

kilometer (abbr. km.). A unit of distance in the metric system.
1 kilometer = 3280.8 feet = 1093.6 yards = 1000 meters = 0.62137 statute miles = 0.53996 nautical miles.

L

laser. (From light amplication by stimulated emission of radiation.) A device for producing light by emission of energy stored in a molecular or atomic system when stimulated by an input signal.

launch. 1. The action taken in launching a rocket from the surface. 2. The resultant of this action, i.e., the transition from static repose to dynamic flight by the rocket. 3. The time at which this takes place. 4. The action of sending forth a rocket, probe, or other object from a moving vehicle, such as an aircraft or spacecraft.

Launch Control Center. Located at the Kennedy Space Center, Florida, and is adjacent to the VAB and connected to the high bay area by an enclosed bridge. All phases of launch operations at Complex 39 are controlled from the four-story Launch Control Center.

lift-off. The action of a rocket vehicle as it separates from its launch pad in a vertical ascent.

A lift-off action performed by a rocket; a launch is action performed upon a rocket or upon a satellite or spaceship carried by a rocket.

light-year. A unit of length equal to the distance light travels in one year.

liquid fuel. A rocket fuel which is liquid under the conditions in which it is utilized in the rocket. See liquid propellant.

liquid propellant (abbr. LP). Specifically a rocket propellant in liquid form.

Examples of liquid propellants include fuels such as alcohol, gasoline, aniline, liquid ammonia, and liquid hydrogen; oxidants such as liquid oxygen, hydrogen peroxide (also applicable as a monopropellant), and nitric acid; additives such as water; and monopropellants such as nitromethane.

liquid propellant rocket engine. A rocket engine using a propellant or propellants in liquid form. Also called liquid-propellant rocket.

lox. 1. Liquid oxygen. Used attributively as in lox tank, lox unit. Also called loxygen. 2. To load the fuel tanks of a rocket vehicle with liquid oxygen. Hence, loxing.

lunar. Of or pertaining to the Moon.

lunar crater. A depression, usually circular, on the surface of the Moon, usually with a raised rim called a ringwall.

Craters range in size up to 250 kilometers in diameters. The largest craters are sometimes called walled plains. The smaller, 15 to 30 kilometers across, are often called craterlets and the very smallest, a few hundred meters across, heads.

Craters are named after people, mainly astronomers.

lunar gravity. The force imparted by the Moon to a mass which is at rest relative to the Moon. It is approximately 1/6 of the Earth's gravity.

Lunar Module. One of the three sections of the Apollo spacecraft. Carries two men from lunar orbit to the Moon's surface for exploration and then back into lunar orbit for rendezvous with the Command and Service Modules.

lunar orbit. Orbit of a spacecraft around the Moon.

lunar probe. A probe for exploring and reporting on conditions

on or about the Moon.

Lunik. Russian term for a space probe launched to the moon's vicinity or to impact on the Moon.

M

magnet. A body which produces a magnetic field around itself.

magnetic. 1. Of or pertaining to a magnet. 2. Of or pertaining to a material which is capable of being magnetized. 3. Related to or measured from magnetic north.

magnetic field. A region of space wherein any magnetic dipole would experience a magnetic force or torque; often represented as the geometric array of the imaginary magnetic lines of force that exist in relation to magnetic poles.

manned. Of a vehicle occupied by one or more persons who normally have control over the movements of the vehicle, as in a manned aircraft or spacecraft, or who perform some useful function while in the vehicle.

manned lander. As the Apollo flights to the Moon.

meteor. 1. In particular, the light phenomenon which results from the entry into the earth's atmosphere of a solid particle from space; more generally, any physical object or phenomenon associated with such an event. 2. A bit of matter from space that glows as it falls through the Earth's atmosphere.

meteorite. Any meteoroid which has reached the surface of the Earth without being completely vaporized.

meteoroid. A solid object moving in interplanetary space, or a size considerably smaller than an asteroid and considerably larger than an atom or molecule.

meteorological satellite. Photographs the Earth's cloud cover and measures infrared (heat) radiation. Tiros I, the first meteorological satellite, was launched on April 1, 1967, giving the weatherman his first long-term observing eye in space.

missile. Any object thrown, dropped, fired, launched, or otherwise projected with the purpose of striking a target. Short for ballistic missile, guided missile.
Missile should not be used loosely as a synonym for rocket or spacecraft.

mobile concept. Provides for assembly and checkout of Apollo/Saturn V vehicles in the controlled environment of a building and their subsequent transfer to launch pad several miles away. This permits more frequent launches.

mobile launcher. Serves as an assembly platform within the Vehicle Assembly Building (VAB, a component of Complex 39 at Kennedy Space Center) and as a launch platform and umbilical tower at the launch site. A 446-foot high structure, the mobile launcher weighs 12 million pounds.

mobile service structure. One of the major components of Complex 39 at Kennedy Space Center. Provides external access to the spacecraft at the launch site.

module. A self-contained unit of a launch vehicle or spacecraft which serves as a building block for the overall structure. The module is usually designated by its primary function as command module, lunar landing module, etc.

molecule. An aggregate of two or more atoms of a substance that exists as a unit.

multistage rocket. A vehicle having two or more rocket units, each unit firing after the one in back of it has exhausted its propellant. Normally each unit, or stage, is jettisoned after completing its firing. Also called a multiple-stage rocket or, infrequently, a step rocket.

N

NACA (abbr). National Advisory Committee for Aeronautics. The predecessor of NASA.

NASA (abbr). National Aeronautics and Space Administration. Historically, establishment of NASA, on October 1, 1958, followed the launch of Sputnik I, the first man-made Earth satellite, which a year before had sparked a world wide chain reaction of events.

Newton laws of motion. A set of three fundamental postulates forming the basis of the mechanics of rigid bodies, formulated by Newton in 1687.

The first law is concerned with the principle of inertia and states that if a body in motion is not acted upon by an external force, its momentum remains constant (law of conservation of momentum). The second law asserts that the rate of change of momentum of a body is proportional to the force acting upon the body and is in the

direction of the applied force. The third law is the principle of action and reaction, stating that for every force acting upon a body there exists a corresponding force of the same magnitude exerted by the body in the opposite direction.

nitrogen. A colorless, tasteless, odorless, gaseous element that constitutes 78 percent of the atmosphere by volume and is a constituent of all living tissues.

nitroglycerine. A heavy oily explosive poisonous liquid obtained by nitrating glycerol and used chiefly in making dynamites and in medicine as a vasodilator.

O

orbiter. A scientific instrument which is an ultrasonic-type scanning device that monitors minute eye movements. It was developed under contract through the MASA Electronics Research Center in Boston for the specific purpose of human factors research.

This device could be experimentally used in a gravity-less environment where the astronaut operates helicopters or the pilot of the airplane reading a foreign language or a metric screen.

orbit. 1. The path of a body or particle under the influence of a gravitational or other force. For instance, the orbit of a celestial body is the path relative to another body around which it revolves.

"Orbit" is commonly used to designate a closed path and "trajectory" to denote a path which is not closed. Thus, the trajectory of a rocket, the orbit of a satellite.

2. To go around the Earth or other body in an orbit, as in number 1 above.

orbital velocity. 1. The average velocity at which an Earth satellite or other orbiting body travels around its primary. 2. The velocity of such a body at any given point in its orbit, as in "its orbital velocity at the apogee is less than at the perigee."

orbiter. An a spacecraft surveys a planet from orbit. NASA's lunar orbiters typify this class.

OSO (abbr). Orbiting Solar Observatory. OSO I was launched by the United States on March 7, 1962. It is designed in particular to gather information on the emission by the sun of x and y rays, ultraviolet light, neutrons, protons, and electrons which cannot be obtained from the Earth's surface.

[illegible] Specifically, a submission that substantially [illegible] suggests that modification of a feature is prejudicial.

[illegible] An argument that is based [illegible] [illegible] [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Assistant Secretary. The head of any branch appointed by the Board [illegible] the Secretary, and all the duties of the Secretary in connection with the branch. The Assistant Secretary shall [illegible] of the Board during his absence, or inability to act, and perform such other duties as may be assigned to him by the Board or the Secretary. The Board is authorized to appoint [illegible] Assistant Secretary, who shall perform such duties as may be assigned to him by the Secretary or the Assistant Secretary in charge of the branch.

Assistant Cashier. One or more Assistant Secretaries [illegible] Assistant Cashier shall perform such of the duties of the Cashier as may be assigned to him by the Board. In the absence or inability to act of the Cashier, the Assistant Cashier shall perform all the duties of the Cashier. The Board may appoint one or more Assistant Cashiers, who shall perform such duties as may be assigned to them by the Cashier or the Assistant Secretary in charge of the branch.

Assistant Managers. One or more Assistant Managers [illegible] Assistant Managers shall perform such of the duties of the Manager as may be assigned to them by the Manager or the Board. In the absence or inability to act of the Manager, one of the Assistant Managers designated by the Board shall perform all the duties of the Manager. The Board may appoint [illegible] Assistant Managers, who shall perform such duties as may be assigned to them by the Manager or the Assistant Manager in charge of the branch.

Assistant Tellers. Assistant Secretaries [illegible] Assistant Tellers, as the Board may determine. Assistant Tellers shall perform such of the duties of the Teller as may be assigned to them by the Teller or the Assistant Teller in charge of the branch. In the absence or inability to act of the Teller, one of the Assistant Tellers designated by the Board shall perform all the duties of the Teller. The Board may appoint [illegible] Assistant Tellers, who shall perform such duties as may be assigned to them by the Teller or the Assistant Teller in charge of the branch. [illegible] Assistant Tellers shall be [illegible] as provided in Section 12 hereof.

Bonded Clerks. 1. The Secretary of State and Auditor shall [illegible] the Secretary, Cashier, or Assistant Cashier of each [illegible] Bonded Clerks, as it deems necessary, [illegible] Bonded Clerks shall perform such duties as may be assigned to them by the Secretary, Cashier or Assistant Cashier of the branch. The Secretary, Cashier or Assistant Cashier of the branch shall be responsible for the [illegible] Bonded Clerks. The Board may require any Bonded Clerk to give a bond [illegible] Bonded Clerks shall be [illegible] as provided in Section 12 hereof.

[illegible]

associated region of the Sun. It affects the structure of the ionosphere and interferes with communications. Giant solar flares are also dangerous to space travelers.

solar-system. The Sun and other celestial bodies within its gravitational influence, including planets, asteroids, satellites, comets, and meteors.

solar wind. Streams of plasma flowing approximately radially outward from the Sun.

solid fuel. A solid propellant.

solid propellant. Specifically, a rocket propellant in solid form, usually containing both fuel and oxidizer combined or mixed, and formed into a monolithic (not powdered or granulated) grain.

solid-propellant rocket engine. A rocket engine fueled with a solid propellant. Such motors consist essentially of a combustion chamber containing the propellant, a a nozzle for the exhaust jet, although they often contain other components, as grids, liners, etc.

space. 1. Specifically, the part of the universe lying outside the limits of the Earth's atmosphere. 2. More generally, the volume in which all celestial bodies, including the Earth, move. 3. That part of the universe between celestial bodies, possibly infinite.

spacecraft. A vehicle designed to perform certain useful functions in space. It may range in size, cost, and complexity from a simple sounding rocket checking radiation to an extremely complicated machine carrying human life.

space medicine. 1. A branch of aerospace medicine concerned specifically with the health of persons who make, or expect to make, flights into space beyond the sensible atmosphere. 2. The branch of medicine concerned with the study, prevention, cure, or alleviation of physical or mental ailments arising from conditions encountered in or brought on by space flight.

space myopia. A condition experienced by space travelers in which the eye is unable to focus on distant objects.

space station. A large orbiting satellite conceived as a habitable base in space with scientific, exploratory, or military applications. Its facilities would provide for the sustenance of man and the storage of supplies. It could be used as a platform for the launch of other space vehicles.

spectrograph. 1. An instrument used to produce a record of a spectrum. 2. A spectroscope with a photographic recording device.

spectroscope. 1. An apparatus to effect dispersion of radiation and visual display of the spectrum obtained. 2. An instrument for producing and viewing spectra. Spectroscopes are used in one instance for identifying gases in a certain atmosphere or enclosure.

spectrum. 1. In physics, any series of energies arranged according to wavelength (or frequency). 2. The series of images produced when a beam of radiant energy is subject to dispersion. 3. Short for electromagnetic spectrum or for any part of it used for a specific purpose as the radio spectrum (10 kilocycles to 300,000 megacycles.)

sphere. 1. The apparent surface of the heavens of which help forms the dome of the visible sky. 2. One of the concentric and eccentric revolving spherical transparent shells in which according to ancient astronomy, stars, Sun, planets, and Moon are set. 3. A globular body.

Sputnik. A Soviet satellite series; the first one was launched on October 4, 1957. It weighed 184.3 pounds; later vehicles weighed more than 10,000 pounds. Sputnik I was the world's first orbiting man-made satellite.

sunspot. A large "dark" spot appearing in the region of the Sun's photosphere, in the 5 to 40 degrees north and south latitude of the Sun. They vary in number, but hit peaks approximately every 11 years. It is believed that the high periods of static and radio interference is directly related to the Sun cycle. The spots themselves appear to be magnetic in character and whirl, much like Earth cyclones. There is no complete explanation for their origin.

T

technology. 1. A technical method of achieving a practical purpose. 2. The totality of the means employed to provide objects necessary for human sustenance and comfort. 3. Applied science.

telemetry. 1. The science of measuring a quantity or quantities, transmitting the results to a distant station, and there interpreting, indicating, and/or recording the quantities measured. 2. The process of transferring information from one point to another remote point by electromagnetic waves.

tracking station. A station set up to track an object moving through the atmosphere or space, usually by means of radar or radio.

trajectory. In general, the path traced by any body moving as a result of an externally applied force, considered in three dimensions.

Trajectory is sometimes used to mean flight path or orbit, but orbit usually means a closed path and trajectory, a path which is not closed.

transporter. One of the major components of Launch Complex 39 at Kennedy Space Center. The transporter transfers space vehicles and Mobile Launchers to launch pads.

U

unmanned lander. Spacecraft softlands on the surface and radios data back to Earth, e.g., America's lunar Surveyor spacecraft.

V

VAB (abbr). Vehicle Assembly Building. One of the major components of Launch Complex 39 at Kennedy Space Center. Facilities for the assembling and testing of space vehicles.

vacuum. A space devoid of matter, or a space on Earth in which the atmospheric pressure has been reduced as much as possible by pumping systems.

Van Allen Belt, Van Allen radiation belt. (For James A. Van Allen, 1915....) The Zone of high-intensity particulate radiation surrounding the Earth beginning at altitudes of approximately 1000 kilometers.

The radiation of the Van Allen belt is composed of protons and electrons temporarily trapped in the Earth's magnetic field. The intensity of radiation varies with the distance from the Earth.

velocity. The rate of motion of a body traveling in a given direction. It is a vector quantity including both magnitude (speed) and direction in relation to a given frame of reference. It is employed in its higher magnitudes as a means of overcoming the force of gravity.

VTOL (abbr). Type of aircraft having a vertical take-off and landing capability.

W

weightlessness. 1. A condition in which no acceleration, whether of gravity or other force, can be detected by an observer within the system in question.

Any object falling freely in a vacuum is weightless. Thus an unaccelerated satellite orbiting the Earth is weightless although gravity affects its orbit. Weightlessness can be produced within the atmosphere in aircraft flying a parabolic flight path.

2. A condition in which gravitational and other external forces acting on a body produce no stress, either internal or external, in the body. 3. The absence of gravity or the balancing of gravitational force with an equal and opposite force, such as with centrifugal force.

APPENDIX - B

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

1. [illegible]

2. [illegible]

[illegible]

3. [illegible]

4. [illegible]

5. [illegible]

[illegible]

a. i. [illegible]

ii. [illegible]

b. [illegible]

i. [illegible]

ii. [illegible]

iii. [illegible]

SUBJECT: SPACE MOTION, GUIDANCE AND DISTANCE

TOPIC: Satellite Orbits

CONCEPT: Type of orbit is determined by the angle of insertion.

MATERIALS:

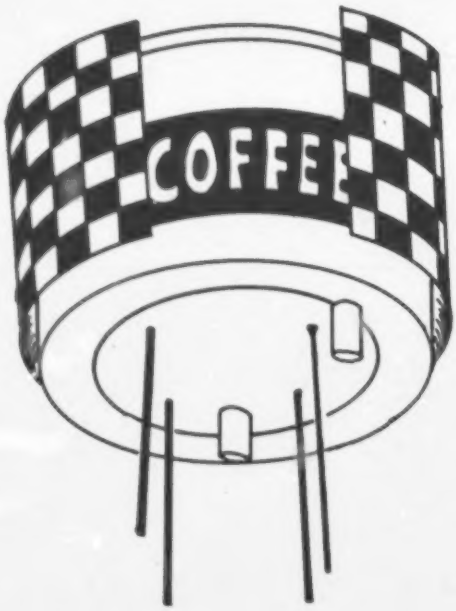
- Basketball
- Coat hanger
- Tape
- Two or three feet of string
- Weight
- Pail
- Thimble

PROCEDURE:

1. Place ball in pail; bend coat hanger and tape to ball; attach string to cap and place it on top; attach weight to string.
2. This device represents earth and satellite.
3. Push weight away from ball and observe how and where it turns.
4. Lightly push weight away at different angles.
5. Experiment with speed, angles, pushing it after it is in motion, etc.
6. Determine what a sub-orbit, elliptical and circular orbit are. Discuss perigee and apogee.

RELATED QUESTIONS:

A. What other factors might affect an orbit, other than angle, speed, etc.
B. Can you develop ways of graphically showing how an orbit is drawn?



SUBJECT — UNMANNED SPACECRAFT

TOPIC — Weather in the Space Age

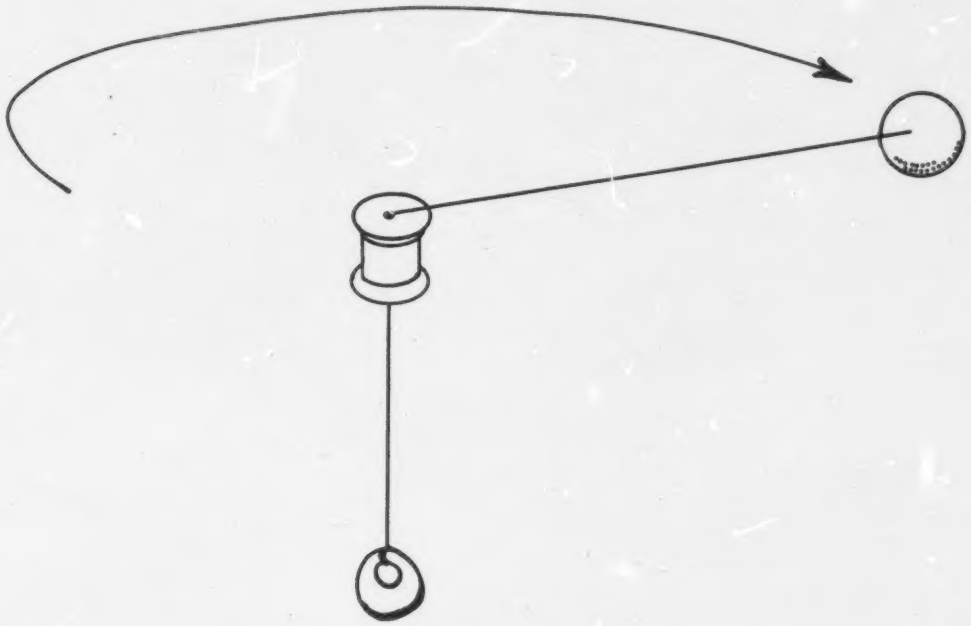
CONCEPT — Weather satellites are helping meteorologists to predict weather more accurately.

MATERIALS

Coffee can — Coat hanger
Tempera paint - blue & white — Art paper
2 Wooden dowels - 1" diameter preferred

PROCEDURE

1. Puncture coffee can on bottom with four holes.
2. Cut coat hangers to desired length (the distance between any two holes) and bend to form a squared U.
3. Insert bent hangers through holes.
4. Cut wooden dowels and glue on the bottom of coffee can 120° apart.
5. Cut art paper to a size necessary to cover sides of can. Paint paper in blue and white checkerboard pattern to resenble solar cells.
6. Discuss Tiros' contributions and future possibilities.



SUBJECT — SPACE MOTION, GUIDANCE AND DISTANCE

TOPIC — Orbit Velocity

CONCEPT — Many forces act upon a space craft as it is orbiting our earth.

MATERIALS

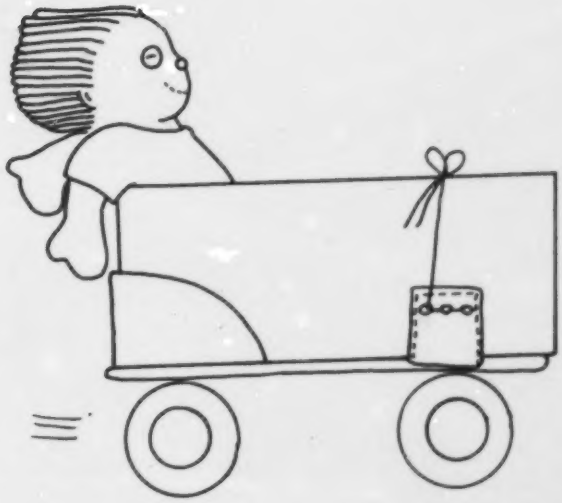
One 3' piece of heavy cord
Sponge baseball
Coat Hanger
Very heavy weight (1 lb.)
Metal sleeve or wooden spool
Wire cutters

PROCEDURE

1. Attach hanger to ball. Run a weighted cord through the sleeve and attach to the eye hook.
2. Swing ball around until velocity of the ball counterbalances the weight.
3. Observe what happens at varying velocities.
4. Determine what forces work on a satellite and what keeps it in orbit.

RELATED QUESTIONS

A. If you cut the string, what would happen to the ball? What would this represent?
B. What do the varying velocities show?
C. How would you show an elliptical orbit using this device?
D. What forces are acting upon the orbiting object?



SUBJECT — MAN IN SPACE

TOPIC — Deceleration of Spacecraft

CONCEPT — A sudden and drastic change in velocity imposes great stress (g-force) on a moving object.

MATERIALS

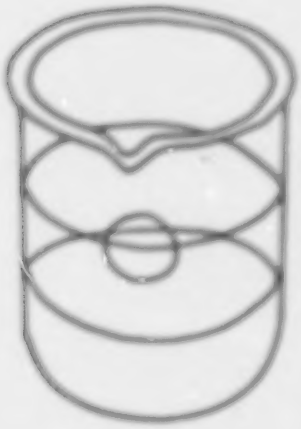
One Roller Skate
Brick
String
Shoe Box
Rag Doll

PROCEDURE

A. Seat a doll at the back end of a shoe box which has been tied to a roller skate.
B. Give the skate a push so that it will roll across the table and hit a brick.
C. Repeat the experiment with the doll sitting with its back against the front end of the box.
D. Note the difference in what happens to the doll in the second collision compared with the first.

RELATED QUESTIONS

1. What is the term we use to describe the increased weight acting upon the doll in both instances?
2. Using the observed results, organize a general statement as to the proper body position for a person undergoing rapid acceleration or deceleration.
3. Relate your findings to manned spacecraft and the position of the astronaut's body in relation to forces acting upon it during lift-off and re-entry.
4. Make a chart of other reasons why these positions are best.



SUBJECT — MAN IN SPACE

TOPIC — "Weightlessness - Handling of Liquids"

CONCEPT — Liquids behave differently in a weightless condition.

MATERIALS

Olive Oil
Rubbing Alcohol
Pencil
Beaker (250 cc)
Water

PROCEDURE

A. Fill the beaker about ¾ full of water.
B. Add a few drops of olive oil (making sure that the oil is together and not scattered).
C. Add alcohol very slowly to be suspended in the water and alcohol solution.
D. Take a pencil and break up the oil globule into many smaller ones.
E. Notice the shape they immediately assume.

RELATED QUESTIONS

1. Considering the nature of the action of the olive oil as demonstrating how liquids behave in a weightless condition, make a general statement that could be applied to the behavior of all liquids in space.
2. How might weightlessness interfere with the following:

   a. Food and water storage?
   b. Capsule housecleaning?
   c. Digestive process?
   d. Fuel storage and pumping?
   e. Others?

SUBJECT: MAN IN SPACE

TOPIC: Space Hazards--Micrometeoroids

CONCEPT: Because small particles travel through space at tremendous speeds, they are easily able to penetrate a spacecraft.

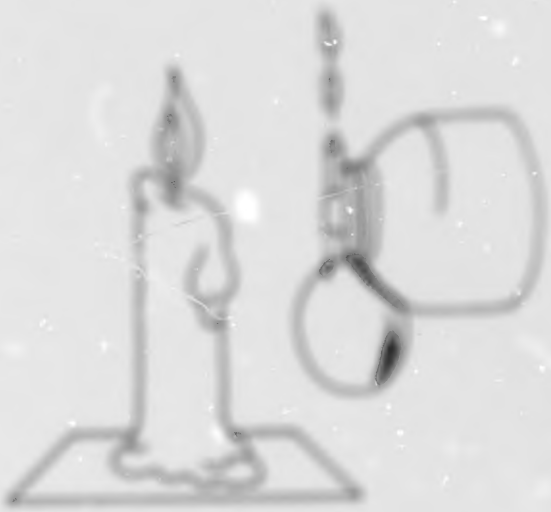
MATERIALS: Paper Stew and Plastic Straws of different sizes, and raw potato

PROCEDURE:

1. Hold the potato in your hand (between the thumb and index finger). Do not hold it in the palm of your hand.
2. With the straw in the other hand, try to drive the straw through the potato.
3. If after a few trys you have no success, try covering the end of the straw with your thumb in order to trap an air column.
4. Just before you attempt to pierce the potato with the straw, bring the potato quickly toward the straw.
5. Repeat, using different sizes of straws.

RELATED QUESTIONS:

A. Relate this activity to particles traveling in space. How do size and speed affect the ability of the straw to penetrate potato?
B. Devise methods by which spacecraft might be protected from meteoroids traveling in space.



SUBJECT [illegible]

TOPIC Rocket Fuel Combustion

CONCEPT By increasing the surface area, you increase ignition and burning rate.

MATERIALS Beaker with alcohol
Candle mounted on cork
Evaporating dish
Epoxy burnin alcohol

PROCEDURE
1. Pipette burning epiet into beaker of alcohol.
2. Light an evaporating dish of alcohol and observe burning rate.
3. Light the candle and let the wax drop on the cork.
4. Mount the candle in the wax before it cools.
5. Holding the epoxy burnin parallel to the flame, spray the alcohol across the flame (keep the epoxy back from the flame two or three feet).
6. Duno the exercise.

RELATED QUESTIONS
a. By spraying the alcohol, why did you get such intense combustion?
b. How might this concept affect the design of a rocket motor?
c. If your clothing was on fire and the only liquid nearby was an open vat of gasoline, would you jump into the vat? Why or why not?

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

1. [illegible]

[illegible]

2. [illegible]

[illegible]

3. [illegible]

[illegible]

4. [illegible]

[illegible]

5. [illegible]

[illegible]

6. [illegible]

[illegible]

7. [illegible]

[illegible]

8. [illegible]

[illegible]

9. [illegible]

[illegible]

10. [illegible]

[illegible]

[illegible]

[illegible]

1. [illegible] (1)

2. [illegible] (2)

3. [illegible] (3)

4. [illegible] (4)

5. [illegible] (5)

[illegible]

1. [illegible] (6)

2. [illegible] (7)

3. [illegible] (8)

4. [illegible] (9)

5. [illegible] (10)

UNIT III

Pre-test Questions
Completion

1. The path in which an artificial satellite circles the Earth is known as its _____.

   Ans. orbit

2. In outer space, the speed of a satellite is reduced by _____.

   Ans. air friction

3. A _____ is a natural or artificial body which orbits around a planet.

   Ans. satellite

4. The _____ is the only natural _____ of the Earth.

   Ans. Moon/satellite

5. The great distance between a satellite in orbit and the Earth is called _____.

   Ans. apogee

Post-test Questions
Multiple Choice

1. An object which man shoots into space to circle the Earth is called (a) a star, (b) an artificial satellite, (c) an asteroid, (d) a meteorite B

2. A man-made Moon will continue in flight if a balance is established between the forward motion of the object and (a) the Earth's gravity, (b) air resistance, (c) thrust, (d) air speed A

3. The speed which must be achieved by a space vehicle to orbit the Earth is (a) 23,000 miles per hour, (b) 13,000 miles per hour, (c) 17,500 miles per hour, (d) 3,000 miles per hour C

4. The Tiros satellites were designed to (a) launch a man into space, (b) study the planet Venus, (c) observe weather conditions, (d) land on the Moon C

5. An astronaut experiences weightlessness (a) on take off, (b) while in orbit, (c) on re-entry, (d) when landing B

6. The smallest distance between the satellite in orbit and the Earth is called (a) perigee, (b) polar orbit, (c) synchronous orbit, (d) escape velocity. A

7. The Van Allen belt is (a) an area for space travel, (b) a safety device for astronauts, (c) a zone of radiation, (d) a time zone around the Earth. C

8. The first man in space was (a) an American, (b) a Russian, (c) an Englishman, (d) a German B

9. The first American astronaut in space was (a) John Glenn, (b) Alan L. Bean, (c) Alan B. Shepard, (d) Neil A. Armstrong. C

10. When the period of a satellite in orbit is the same as that of the Earth, it is said to be in an elliptical orbit, (b) a synchronous orbit, (c) a polar orbit, (d) a parking orbit B

11. What two major conclusions were drawn from Project Mercury?

    Ans. 1. These flights showed that man could exist in a weightless condition in space for some time.
    2. These flights showed that astronauts could exert some control over their vehicle while in orbit.

12. What did the first manned flight of Project Gemini show?

    Ans. It showed that astronauts could change the orbital path of their spacecraft.

13. What major accomplishment did Astronaut Edward H. White perform during the second flight of Project Gemini?

    Ans. He left the space capsule, staying outside for 22 minutes.

14. Name three functions of satellites.

    Ans. 1. Observe and report on weahter
    2. Help navigators at sea
    3. Communications

15. What is a space probe?

    Ans. A space probe is any vehicle launched into space to explore the Moon or any of the planets.

16. Indicate the prime target for each of the following space probes:

A.	Ranger	Moon
B.	Surveyor	Moon
C.	Mariner II	Venus
D.	Mariner IV	Mars

17. Match the following terms and statements.

1.	E	plasma fuel
2.	F	open orbit
3.	H	polar orbit
4.	B	perigee
5.	G	apogee
6.	C	closed orbit
7.	D	equatorial
8.	A	orbit

A. Occurs when a spaceship circles the Earth.
B. Is the closest orbital point to Earth.
C. Occurs when orbital velocity is reduced.
D. Occurs when a space ship circles the equator.
E. Gives off energy when an electric spark is sent through it.
F. Occurs when a space ship reaches escape velocity and does not circle the Earth.
G. Is the farthest orbital point from the Earth.
H. Occurs when a spaceship travels over the north and south poles

UNIT IV

Pre-test Questions

1. Number the following events of Project Apollo in their proper time sequence.

A.	8	The service module is discarded.
B.	1	The Saturn V serves as a Launch vehicle.
C.	5	Two of the astronauts investigate the Moon.
D.	4	Retro-rockets are used for Moon landing.
E.	2	The spaceship is attached to the last stage.
F.	3	The command and service units turn 180°.
G.	6	The LEM is discarded.
H.	7	The service module blasts the command unit out of the Moon's orbit.

Post-test Questions
True-false

1.	A payload can only be carried by one rocket.	False
2.	Attaching one rocket on top of another is called staging.	True
3.	An orbital rendezvous occurs when one spaceship finds another in space.	True
4.	A very small error in the initial guidance of a spaceship could put it off course as much as 20,000 miles.	True
5.	Astronauts are placed so that they are lying down during takeoff so that their weight is distributed evenly. This helps reduce the possibility of trauma and of pooling of blood in the lower extremities.	True
6.	The useful cargo carried on a space mission exclusive of propellants, the frame and tanks, or heat-shield, is called the payload.	True
7.	The primary purpose for the landing of astronauts on the Moon was to establish a space station.	False
8.	The three-man Apollo spacecraft in which the astronauts journey to the Moon consists of two sections, the command module and the lunar module.	False
9.	Of the three astronauts who travel to the Moon, only two actually set foot on the Moon.	True

10. Special alloys that are heat resistant and a fiber glass shield that absorbs heat as it melts protects a space capsule against burning up upon re-entry to the Earth's atmosphere. True

Completion

11. The _____ module of the Apollo spacecraft is designed to allow three men to eat, sleep and work in it without wearing pressure suits.

Ans. Command

12. The section of the Apollo spacecraft which contains supplies, fuel and a rocket engine is the _____ module.

Ans. service

13. The _____ module carries the astronauts and the fuel necessary to slow down the fall to the Moon and make a soft landing as well as fuel for returning to the _____ module.

Ans. lunar/command

14. Apollo 15 astronauts used for the first time a _____ _____ vehicle which significantly enhanced their ability to explore the surface of the Moon.

Ans. lunar roving

UNIT V

Pre-test Questions
True-false

1. Apollo, the second largest and most complex of the manned space flight programs, had as its goal the landing of astronauts on the Moon and their safe return to Earth. False

2. The Apollo program is directed by the Office of Manned Space Flight, NASA, Washington, D. C. True

3. The widespread efforts in Project Apollo are centered in three large NASA installations, the Manned Spacecraft Center at Houston, Texas, the Marshall Space Flight Center at Huntsville, Alabama, and the Kennedy Space Center in Florida. True

4. The Manned Spacecraft Center at Houston, Texas, assembles and tests the rockets and spacecraft, moves the upright space vehicle to the launch pad, and conducts the launches. False

5. The Marshall Space Flight Center in Huntsville, Alabama, is responsible for development of the giant 280-foot-tall Saturn V launch vehicle. True

Post-test Questions
True-false

1. The Kennedy Space Center in Florida selects and trains the astronauts, develops the spacecraft, and conducts the flight missions. False

2. Apollo 8 was the first manned flight of the lunar module, and completed successfully attempts to separate and rendezvous. False

3. Apollo 9, with astronauts Frank Borman, James Lovell, and William Anders, carried men on the first orbit of the Moon. False

4. Apollo 10 completed all orbital maneuvers required for landing on the Moon except for actual landing. True

5. The first man to set foot on the Moon, Astronaut Neil A. Armstrong, accomplished this feat at 10:56 p.m., E.D.T., Sunday, July 20, 1969. True

Match the following terms and statements.

1. ___ Extravehicular
2. ___ Tranquility
3. ___ Apollo 11
4. ___ Rendezvous
5. ___ Communications Satellites
6. ___ Lunar Module
7. ___ Earth Food Conversion
8. ___ Apollo 12
9. ___ Five Hours
10. ___ Meteorological Satellites
11. ___ Apollo 13
12. ___ Safety Pills
13. ___ Breathing Hoses
14. ___ Apollo 14
15. ___ Descartes
16. ___ Oxygen
17. ___ Apollo 15
18. ___ Cryogenic Insulation
19. ___ Solar Cell
20. ___ Apollo 16

a. The meeting of two space vehicles at a given point and time in space, and the place at which this takes place.

b. Experimental base established on the Moon by Astronauts John W. Young and Thomas K. Mattingly.

c. Used in experiments on the Moon to detect Moonquakes.

d. Astronauts used the Lunar Roving Vehicle for the first time.

e. Flight by James Lovell, Fred Haise, and Jack Swigert called "Success-Ful Failure."

f. Astronauts Charles Conrad, Jr., Alan L. Bean, and Richard F. Gordon, Jr. made this flight.

g. Encountered docking difficulties in space.

h. Three series

i. Astronauts set a record in conducting three extravehicular activities totaling 21 hours.

j. Astronauts left plaque on the Moon--"Here Men From Planet Earth First Set Foot Upon the Moon July 1969 A.D."

k. Experimental base on the Moon established by Charles Conrad, Jr., and Alan L. Bean.

l. Experimental base established on the Moon by Astronauts Neil A. Armstrong and Edwin "Buzz" Aldrin, Jr.

m. Experimental base on the Moon by Astronauts Alan B. Shepard and Stuart A. Roosa.

[illegible]

[illegible]

[illegible]

1. [illegible]

   Ans. [illegible]

2. [illegible]

   Ans. [illegible]

3. [illegible]

   Ans. [illegible]

4. [illegible]

   Ans. [illegible]

5. [illegible]

   Ans. [illegible]

[illegible]

1. [illegible] [illegible]

2. [illegible] [illegible]

3. [illegible] [illegible]

4. [illegible] [illegible]

[illegible]

[illegible]

[illegible]

4. Unlike Project Apollo, the Man on Mars Project will not have to utilize unmanned spacecraft as a beginning but go directly to manned flights. False

5. Mariner IX was successfully launched on May 30, 1971 and arrived at Mars on November 13, 1971. True

Match the following terms and statements.

1. B ERTS
2. E Space benefit to man in agriculture
3. G Space benefit to man in Oceanography
4. D Space benefit to man in Hydrology
5. J Space benefit to man in Geology
6. F Space benefit to man in Cartography
7. H Apollo 17
8. A Skylab
9. C Space Shuttle
10. I Man on Mars Project

A. Experimental space station program of NASA which is scheduled for April 1973.
B. NASA's Earth Resources Technology Satellite Program began at Goddard Space Flight Center in 1966.
C. Goals are to bring into operation a fully reusable vehicle capable of carrying up to 50,000 pounds of payload on both legs of the round trip between Earth and Earth orbit.
D. Through cameras and infrared, control and early warning of floods by monitoring rain fall, weather prediction, and drainage basin surveys.
E. Through infrared and microwave, estimation of soil moisture content and inigation requirements.
F. Through cameras, construction of detailed maps of rural and urban areas to help plan traffic arteries and terminals.
G. Through cameras, infrared, and microwave, location of high biological activity from surface temperature for fishing fleets--large schools of surface-feeding fish may also be pinpointed.

H. Last manned space flight, scheduled for December 1972.
I. Manned flights similar to Apollo lunar missions may be attempted in the 1980's.
J. Through cameras, infrared, and microwave, prediction of earthquakes from slight temperature differences, soil moisture content, and topographical distribution.
K. Spacecraft surveys the planet from orbit.

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